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GUIDELINES FOR SIMULATOR-BASED MARINE PILOT TRAINING PROGRAMS

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Project Managers: Dr. John Gardenier, USCG; Joseph Puglisi, MARAD
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16. Abstracts

This report contains information relating to the proper use of a shiphandling/ship bridge simulator by marine pilots for training purposes. It identifies a number of pilot skills that should be considered for acquisition or enhancement via simulator-based training. It provides information regarding the three major elements of the training system: the simulator design, the training program structure, and the instructor qualifications. This information is presented in a format to assist the potential user of simulator training at the marine pilot level in the identification and evaluation of the benefits to be derived from a given training system. The U.S. Coast Guard has indicated that it plans to use these guidelines for approving ship simulator training courses for partial licensing credit. Keywords:

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PREFACE

This guidelines document is one of the major products resulting from the Pilot Training Investigation Project. An important element of the success of this applied research project lies in the involvement of the maritime industry, particularly the U.S. domestic pilot community, throughout the various stages of the project. Several piloting organizations and individual pilots provided assistance to the project, and hence indirectly to the development of these guidelines. The insights and information they provided greatly assisted in the conduct of the project. The authors would like to express their thanks to the following organizations for the cooperation, hospitality and insight provided by their representatives:

- United New York New Jersey Sandy Hook Pilot Association
- Pilot Association for the Bay and River Delaware
- Charleston (S.C.) Branch Pilot Association
- Tampa Bay Pilots
- Crescent River Port Pilots
- Corpus Christi Pilots
- San Francisco Bar Pilots
- Jacobsen Pilot Service
- Northeast Pilot Association
- Houston Pilots
- Rotterdam (Netherlands) Pilots
- Maritime Research Institute Netherlands
- Bremen Nautical School
- Hamburg Polytechnic
- Brotherhood of German Pilots
- Exxon U.S.A.

It should be noted that participation by these organizations does not imply their agreement with aspects of the Pilot Training Investigation Project, this report or other reports of the project.

A special note of appreciation must be given to Captain W. Lascelle (United New York New Jersey Sandy Hook Pilot Association) and Captain J. Bradley (Pilot Association for the Bay and River Delaware) for their assistance, particularly during the design and conduct of the experimental training program at CAORF, upon which much of the information contained in the guidelines is based. Captain Lascelle and Captain Bradley should also be thanked for their careful review of relevant concepts and materials throughout the project. It should be noted that this report represents the authors' findings and recommendations, which may or may not reflect the views of these two individuals.

A special debt of gratitude must also be acknowledged to Captain C. DeBoer (Rotterdam Pilots) who provided the project team with a wealth of information on pilot simulator training, including the opportunity to observe first-hand the simulator training of Dutch pilots.

Finally, the authors would like to thank the Government's project managers, Dr. J. Gardenier (U.S. Coast Guard) and Mr. J. Puglisi (Maritime Administration), and the U.S. Coast Guard project monitor LCDR O. Naccara for their guidance, assistance, and timely contributions to the success of the project.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In recent years shiphandling/ship bridge simulators have emerged as a potentially valuable training device for developing selected skills for a variety of mariners. Several companies, such as Exxon and Shell, have ongoing simulator training programs for their deck officers. Maritime unions, such as the International Organization of Masters, Mates and Pilots (MMP) and the District 2 - Marine Engineers Beneficial Association - Associated Maritime Officers (MEBA-AMO), have acquired or are presently acquiring simulator-based training facilities for utilization by their members. The U.S. Merchant Marine Academy now has a required simulator-based training course for their deck cadets. In addition, the U.S. Coast Guard Academy, the various state maritime academies, and the U.S. Navy are also investigating simulator training as a supplement to their traditional training techniques.

Successful simulator-based training programs for pilots have been in operation in both the Netherlands and Germany for a number of years. In the Netherlands, all Rotterdam/ Europort pilots, prior to piloting VLCC's with drafts over 57 feet, receive simulator training at the Netherlands Ship Model Basin (NSMB) in Wageningen. This training has been conducted since 1975. It has recently been expanded to include deep draft pilots from the port of Ymuiden. In Germany, Wilhelmshaven, Bremerhaven, and Bremen pilots have participated in simulator training at the Bremen Nautical School. This training started in September 1978. The German pilots also train on the shiphandling/ship bridge simulator at the Hamburg Polytechnic.

The number of training facilities offering shiphandling/ship bridge simulator training within the U.S. and abroad has been increasing steadily. In this country, Marine Safety International (MSI) has been training deck officers since 1976. Ship Analytics began using its simulator for training in 1980. The full mission simulator at the MMP's Maritime Institute of Training and Graduate Studies (MITAGS) became operational in 1982, while the MEBA-AMO simulator is scheduled to go on-line later this year. This modest, but steady increase in the number of simulator training facilities, and hence the availability of this type of training is expected to continue over the next several years.

The reception of the simulator-based training concept among U.S. pilots has been mixed for a variety of reasons. However, there does appear to be a constituency which believes that simulators do have a role in the pilot training process although they are not sure exactly what that role should be. The U.S. Coast Guard has taken the position of encouraging pilots to "...give consideration to the use of simulators in the pilot training process" without defining the specific training that should be considered or

the potential license credit that may be available (Federal Register, 1983).

1.2 CAORF RESEARCH PROJECT

During the past several years, the Maritime Administration and the U.S. Coast Guard have sponsored a research program at the Computer Aided Research Facility (CAORF) to investigate a number of issues relating to the proper role of simulators in the training process of deck officers. This research program has completed the following:

- Compiled an extensive information base relating to deck officer tasks, training objectives, simulator characteristics, and training programs
- Empirically investigated the effectiveness of different simulator characteristics for training senior deck officers and maritime academy cadets.
- Developed guidelines to be used by mariners for the design and use of simulator-based shiphandling training systems for senior deck officers and maritime academy cadets.

This CAORF research has generated substantial information showing that shiphandling/ship bridge simulators have both strengths and limitations as training devices. They are beneficial for assisting students to acquire selected, but not all, mariner skills. They should generally be viewed as a supplement to, not a replacement for, traditional training methods.

The effectiveness of shiphandling simulators to assist pilots in improving their proficiency, as mentioned earlier, has been questioned in the U.S. Hence, this research program was extended to investigate the training of pilots on a simulator. During this research simulator-based training was found to have potential for pilots. Such training was found to be effective for several areas of piloting skills, and for pilots with limited experience and extensive experience. The findings further suggest that the skills for which a simulator would be most effectively used may differ based on the extent of an individual's piloting experience. The description of this experiment together with the detailed analysis and findings, is reported in **Experimental Evaluation of Simulator-based Training for Marine Pilots** (Hammell, Gynther, and Pittsley, 1984).

This guidelines document is a major product of the Pilot Training Investigation Project. It provides guidance information regarding the design and use of simulator-based training systems for pilots. The information contained in the guidelines is based on the analysis and findings of the Pilot Training Experiment conducted on the CAORF simulator, and the overall information generated during this multiphase research program, tailored specifically to the issues relevant to piloting.

1.3 REPORT OBJECTIVES

These pilot training system guidelines are modeled after the similar set of guidelines previously developed under this program for senior level deck officers. These previously developed guidelines documents have been used by the U.S. Coast Guard to determine course approvals for partial licensing credit. These guidelines are also intended as a consumers guide for the operational pilot, and piloting organizations, not the simulator designer. Their purpose is to educate

pilots within the United States as regards the potential of the shiphandling/ship bridge simulator for use as a training supplement. This guide has the following objectives:

- Document relevant information concerning shiphandling/ship bridge simulator-based training for pilots.
- Provide the potential user of simulator-based training at the pilot level with information to assist in the identification and evaluation of the benefits to be derived from a given training system (i.e., simulator, training program).
- Provide recommendations to assist piloting organizations in effectively developing and using simulator-based training programs.
- Guide Coast Guard approval of courses for partial licensing credit.

1.4 REPORT ORGANIZATION

Chapter 2 of this report identifies a number of specific pilot skills that should be considered for acquisition or enhancement via simulator-based training. These skills were identified as a result of the analysis conducted during preparations for the Pilot Training Experiment on the CAORF simulator. This section should be particularly helpful to pilots and pilot associations attempting to define how simulators could improve or refine their existing training programs.

Chapter 3 of this report contains guidance with regard to the three major elements of a simulator-based training system: the simulator, the training program, and the instructor. For each of these major elements, a number of critical characteristics (e.g., horizontal field of view) are defined and discussed as they relate to the training of pilots. In addition, where appropriate, alternative levels of these characteristics (e.g., 60, 120, and 240 degrees) are also identified and discussed. This section attempts to provide the interested pilot or pilot association with a basic understanding of the relevant technical aspects of simulators and simulator-based training.

Finally, Chapter 4 of the report contains sets of recommended and minimum training system characteristics for each of the ten training modules/skill categories identified in Chapter 2. This section should be particularly helpful to pilots or pilot associations when evaluating a given facility's capability for training selected piloting skills prior to enrollment of students; or when developing an effective simulator-based training program to supplement existing programs.

CHAPTER 2

CANDIDATE TRAINING MODULES FOR MARINE PILOT SIMULATOR TRAINING

2.1 GENERAL

As outlined in the previous section, the evidence presently available from several sources indicates that pilots can derive benefit from simulator-based training. This statement does not imply that present proficiency levels are inadequate or that traditional training methods are obsolete. Rather, it simply means that pilots can improve selected skills via properly designed and properly conducted simulator-based training. As a result, the simulator-based training device should be considered by pilots and pilot associations as a possible training medium within their available repertoire. The purpose of this section of the report is to assist interested parties in identifying the pilot skills that should be considered for acquisition and enhancement via simulator-based training.

2.2 APPROACH

Ten training modules, each addressing different areas of piloting skills, have been identified. These are a result of the analysis conducted during the preparations for the Pilot Training Experiment. Empirical data collected during that analysis has shown the simulator-based training can improve proficiency for the skills addressed by two of the modules -- Advanced Instrumentation, and Emergency Shiphandling. Although hard data has not been generated regarding the remaining eight modules, the highly structured analysis process used to identify them, together with the consistency of findings pertaining to these two modules and the findings of earlier research in this program, suggest that the remaining modules can be recommended with a good degree of confidence. It should be noted that not all modules will be appropriate for all pilots. Several apply only to apprentice pilots; some apply only to experienced pilots; several apply to pilots at any level. Paragraph 2.4 identifies, describes, and discusses each of these ten modules in detail.

It should be noted that, throughout the project, the project team established and maintained a working relationship with the pilot community. During the early stages of the research, the project team visited the following U.S. ports for the purpose of discussing the project with pilots and gathering relevant information:

- New Orleans
- New York
- Houston
- Philadelphia
- Providence
- Tampa

Members of the project team also visited the Dutch and German facilities presently involved in training pilots as noted in Paragraph 1.1. The insight obtained from these discussions with both training facility personnel and European pilots, who had participated in simulator training, was a welcomed source of information for this research effort. It was par-

ticularly helpful in the design and conduct of the experimental training program at CAORF.

Two senior, experienced pilots, one from the United New York New Jersey Sandy Hook Pilot Association and the other from the Pilot Association for the Bay and River Delaware, were retained as consultants. These individuals provided the project team with invaluable technical information on piloting, including the concerns of pilots as regards simulator training. Finally, twelve pilots from eight different piloting organizations participated in the project's experimental training program, assisted in its evaluation and provided information relevant to the development of these guidelines. It is believed that this extensive liaison with the pilot community has provided a solid basis for the development of a document that would be useful to those pilots and pilot associations considering shiphandling/ship bridge simulators for training purposes.

2.3 GENERIC VERSUS PORT-SPECIFIC TRAINING

Marine pilot expertise is focused on two subjects: detailed local knowledge and precision ship control. Simulator-based training can help apprentices in both aspects, but cannot be expected to improve experienced pilots' local knowledge. Even for apprentices, existing training programs seem adequate for imparting local knowledge; the benefits of shifting some or all of such training to a simulator are not clear except in cases of new ports or where channels in an existing port are being significantly re-engineered. Then simulator training can help prepare all pilots for the new situation.

Training in a generic port has proven highly satisfactory in this study and in some European experience. It has several attractions over modeling many specific ports:

1. Costs of the generic port data base can be spread over more pilot trainees.

2. Pilots are not tempted to focus on minor discrepancies between the simulation and "their" port.

3. Pilots may be less threatened by the possibility of making an error during training if that "error" does not occur in "their port."

4. Bringing pilots of varying experience and locales together enables valuable interchange of ideas.

5. A generic port can be "fine-tuned" for a problem to aid specific training objectives. Doing the same to a real port invites criticism for "not being real."

6. A generic port can have high relevance to specific ports if its problems are realistically based on conditions which occur in the real ports the pilots come from. (Problems should be designed with that in mind.)

Finally, there is no intent to discourage the use of specific port data bases for simulator-based training of pilots where such is clearly desired and affordable. Rather this discussion is intended to clarify the advantages of generic ports for pilot training despite the fact that they do not simulate the pilots' specific local area.

2.4 CANDIDATE MODULES

The following training modules have been identified as having potential for pilot simulator training. While reviewing these modules, the reader should keep in mind three points. First, an individual pilot's experience and local piloting conditions will impact the relevance of each module for him. The recommended experience level for each simulator training module has been indicated after the title of each module. Second, the training modules listed represent the majority of skill areas that appear appropriate for simulator training at its present level of technological development. As shiphandling/ship bridge simulators improve additional training modules, such as berthing and unberthing large vessels, may become appropriate. Third, these training modules may be administered as individual training programs. or selected modules may be structured as units within a larger training program. This would naturally depend on the specific needs of the students and the specific capabilities/constraints imposed by the training facility. Guidance regarding the recommended minimum simulator characteristics, training program structure, and instructor qualifications for each training module is provided in Paragraphs 3.2, 3.3 and 3.4 respectively. The ten modules recommended as appropriate for the simulator-based training of pilots are summarized in Figure 1. A description of each module follows.

2.4.1 Emergency Shiphandling (All Pilot Levels)

The skills relating to the handling of vessels, particularly large vessels, under emergency conditions fall into a category that is a prime candidate for simulator-based training. It is generally recognized that little at-sea training for emergencies occurs due to the high cost and high risk involved in utilizing actual vessels. Both Dutch and German pilots train for emergency situations on their respective simulators. Emergency situations as used here involve not only steering or propulsion power casualties, but also difficult or unusual maneuvers that would only be attempted in an emergency situation, such as turning the ship around in a narrow channel without tugs. Once individuals have acquired the desired emergency shiphandling skills, refresher training at periodic intervals may be desirable since, during normal piloting there is usually little opportunity to practice and maintain such skills. The following are examples of the behavioral content of several training objectives that appear appropriate for emergency shiphandling:

- Demonstrate proficiency in handling selected vessels during a crash stop within confined channels under various operational conditions.
- Demonstrate proficiency in turning around selected vessels within a confined channel under various operational conditions.
- Demonstrate proficiency in handling selected vessels after a loss or degradation of propulsion power within confined channels under various operational conditions.
- Demonstrate proficiency in handling selected vessels after a loss or degradation of steering within confined channels under various operational conditions.
- Demonstrate proficiency in handling selected vessels when placed in various unusual operational conditions. These unusual conditions shall include as a minimum:

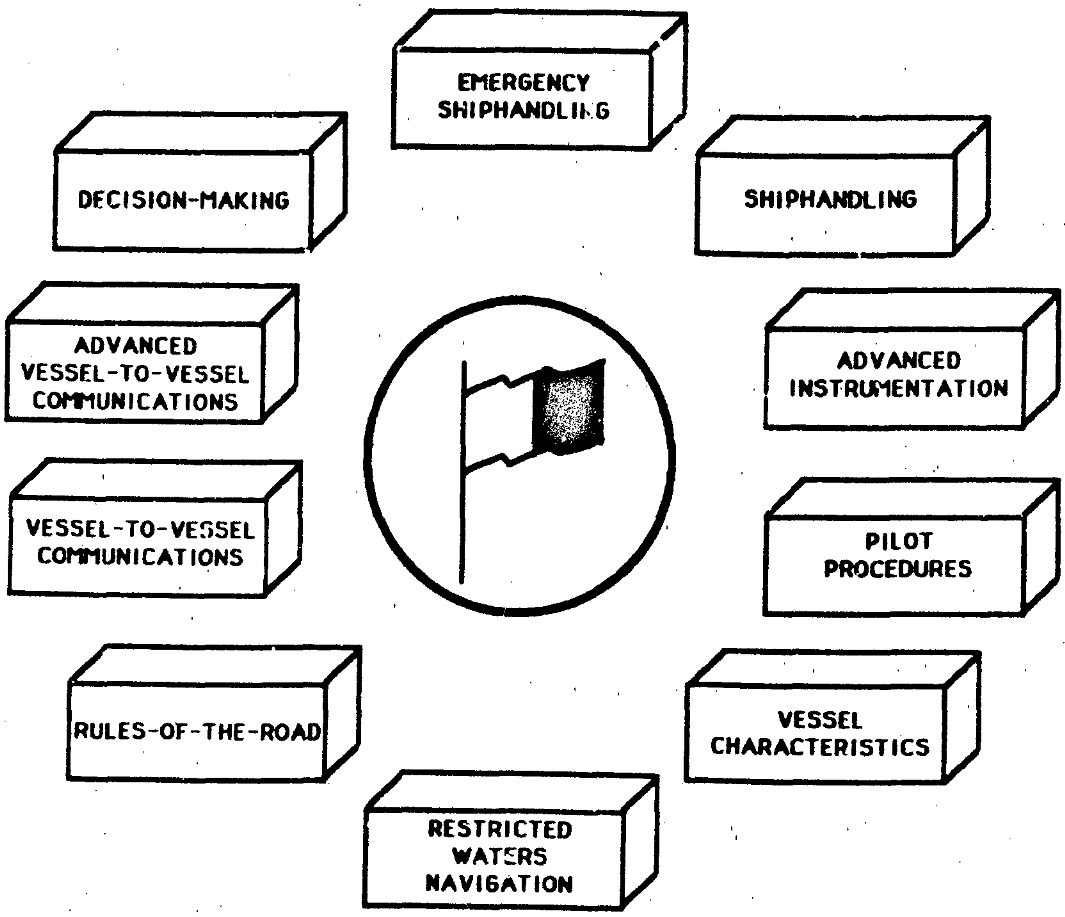

Figure 1. Candidate Marine Pilot Simulator-Based Training Modules

1. Unanticipated channel restrictions or obstructions
2. Serious misunderstandings in the pilothouse
3. Extremis traffic situations

It should be noted that "emergency shiphandling" as envisioned in this training module involves the execution of selected shiphandling maneuvers in emergency or unusual operational conditions. The emphasis is envisioned to be on the proper execution of selected maneuvers, not the early detection of a problem, the identification/evaluation of alternative solutions, and the selection of the appropriate shiphandling action. It is anticipated that these aspects of the piloting process be addressed during the Restricted Water Decisionmaking Module. It is also recommended that apprentice pilots completely master all normal shiphandling skills prior to enrolling in an emergency shiphandling training program.

Care should be exercised when selecting emergency maneuvers to be executed on the simulator. It should be verified that the particular training system can handle satisfactorily all anticipated hydrodynamic effects, anchor forces, tug forces, etc. Specific maneuvers may require a degree of simulation fidelity that has not been adequately developed and tested by the training facility. It is recommended that several senior pilot from the association check out the exercises to ensure that such effects are satisfactory for the training purposes envisioned.

Successful emergency shiphandling training can occur in a generic data base, although a port-specific data base may be required for special training requirements as identified by individual pilot associations. The experimental CAORF training program, which included emergency shiphandling training, employed a generic data base.

2.4.2 Shiphandling (Apprentice Pilots)

A principal advantage of simulator-based training systems over at-sea training lies in the degree of control that can be exerted over the training process. Exercises can be structured to emphasize specific shiphandling principles. They can be repeated or manipulated as appropriate to allow the trainees to more rapidly understand the concepts involved. As a result of participating in simulator-based training, it is anticipated that apprentices may be able to derive greater benefit from later at-sea transits. A second advantage of simulator-based training is better control by the school or pilot association of each apprentice's progress. Simulator-based training can accommodate the focusing of drill on weak areas more easily than can be accomplished at sea. The following are good examples of specific simulator-oriented training objectives which are useful for apprentice pilots.

- Effectively determine safe vessel speed when handling a variety of vessel types and sizes under various operational conditions.

- Effectively maneuver a variety of vessel types and sizes in order to maintain a dead-reckoning (DR) track under various operational conditions.

- Effectively maneuver a variety of vessel types and sizes in order to avoid collision and pass at a safe distance with other traffic under various operational conditions.

- Effectively maneuver a variety of vessel types and sizes when meeting or overtaking other vessels within

confined channels under various operational conditions.

- Safely anchor a variety of vessel types and sizes under various operational conditions.

It should be noted that skills involving the berthing and unberthing of vessels have been specifically omitted from the above listing. The proper training of these skills require special design considerations which are not normally incorporated in present shiphandling/ship bridge simulators (see discussions concerning horizontal and vertical field-of-view in Paragraph 3.2.1).

It is anticipated that numerous shiphandling training objectives for apprentice pilots can be accomplished within a generic data base. However, individual pilot associations may identify special training requirements that may necessitate the use of a port-specific data base. It should be noted that a port-specific data base need encompass only those areas of the port which are pertinent for the desired training.

2.4.3 Vessel Characteristics (Experienced Pilots)

Periodically vessels with unusual size, unusual handling characteristics, or unusual risk commence trade through various U.S. ports. The characteristics of such vessels may differ from those of vessels that have traditionally entered the port such that it may be advantageous for the pilot association to consider a training program for acclimating their members to these new ships prior to their initial pilotage. Liquefied natural gas (LNG) vessels are one ship type that may fall into this category for many pilot associations. A shiphandling/ship bridge simulator should be considered as a particularly appropriate vehicle for such training, provided that adequate ship motion study has been completed to allow realistic modelling of the specific ship class involved. Caution should be exercised that the hydrodynamic and aerodynamic models for the vessel have been validated in a prudent manner. It may be desirable to request the assistance of pilots from other associations who have handled the actual vessel to check-out the vessel's response on the particular simulator being considered for the training.

In certain ports, the mix of ship types may be such that the pilot association may consider it desirable to train and designate a subset of pilots for handling one type of vessel that may be particularly difficult or dangerous. Once again shiphandling/ship bridge simulator appears particularly well-suited for such training. The Dutch pilots follow this procedure for the ULCC's (draft greater than 57 feet) which enter Rotterdam.

The following are example of the behavioral content of several training objectives that should be considered for the simulator-based training of specific vessel characteristics:

- Demonstrate proficiency in assessing the impact of various loading/ballast conditions on the maneuvering characteristics of selected vessels.

- Demonstrate proficiency in assessing the impact of various water depth conditions on the maneuvering characteristics of selected vessels.

- Demonstrate proficiency in assessing the impact of various wind and current conditions on the maneuvering characteristics of selected vessels.

- Demonstrate proficiency in assessing the impact of various bank configurations on the maneuvering characteristics of selected vessels.

- Demonstrate proficiency in assessing the impact of various anchor and tug forces on the maneuvering characteristics of selected vessels.

Once again, although it may be desirable, a port-specific data base does not appear to be required for training vessel characteristics. Of course, each pilot association should analyze and establish its own training requirements.

2.4.4 Pilothouse Procedures (Apprentice Pilots)

Pilot associations should consider simulator training as a viable means of ensuring that apprentices acquire proper pilothouse procedures. The training control which can be offered by the simulator allows the apprentice pilot's interaction with a variety of masters and crews to be analyzed and critiqued under selected conditions. In recent years, there has been considerable emphasis for employing simulators to eliminate "competent error" by encouraging ship crews to actively support and verify the pilot's navigation of the vessel. "Competent error" is the concept that even a highly proficient individual can make mistakes and that the safety of a vessel should not rest solely on the perception and judgement of the individual directing the movements of the vessel. Rather, the navigation process should be checked by several people, one of whom should recognize and call attention to a possible hazard before it became catastrophic. Simulator training programs for ship's personnel in "Bridge Team Training" and "Navigation Management" are becoming more common. From the pilot's perspective, pilots should <u>not</u> be trained to expect support from the ship's crew, but neither should they neglect or feel threatened by such support when it is available. Simulator training programs with the following types of objectives may be one means of attaining the proper level of awareness:

- Familiarize oneself with the following characteristics of the vessel in a timely and effective manner upon boarding:

  - Vessel draft
  - Vessel handling characteristics
  - Type, capability, and operational status of engineering plant
  - Location and operational status of critical pilothouse equipment

- Conduct pretransit discussions with the master in a timely and effective manner in order to agree upon the essential features and relevant checkpoints of planned ship maneuvers. They shall include but are not limited to:

  - Docking instructions
  - Ship speed/ETA
  - Navigational hazards
  - Piloting strategies
  - Use of tugs
  - Use of docking pilots
  - Availability of line handlers at berth

- Communicate with the master and crew in a timely and effective manner during the transit under a variety of operational conditions. These conditions shall include as a minimum:

  - Propulsion power failure
  - Steering failure
  - Crew with a limited understanding of the English language

- Verify in a timely manner the execution of his helm and engine orders under various operational conditions.

- Encourage the ship's crew to monitor the vessel's position during the transit and report significant deviations from the intended track.

It is anticipated that successful training in these skills may be accomplished within a generic data base, although a port-specific data base would be desirable. Care should be exercised that the scenarios presented using the generic data base are relevant to those encountered within a pilot's own port.

2.4.5 Advanced Instrumentation (All Pilot Levels)

Pilots can benefit from simulator-based training that addresses the application of recently developed electronic navigation aids. Examples of such aids, for which simulator-based training may be helpful, include the rate-of-turn indicator, doppler speed log, and racon. Both the Wageningen (the Netherlands) and Bremen (Germany) facilities address advanced instrumentation in their marine pilot simulator training programs. The results of the CAORF Pilot Training Experiment also support this application. The following are examples of the behavioral content of several training objectives for this area of training:

- Demonstrate proficiency in interpreting and utilizing the information provided by various radar and collision avoidance systems under a variety of operational conditions.

- Demonstrate proficiency in interpreting and utilizing the information provided by various doppler speed and docking logs under a variety of operational conditions.

- Demonstrate proficiency in interpreting and utilizing the information provided by various rate-of-turn indicators under a variety of operational conditions.

- Demonstrate proficiency in interpreting and utilizing the information provided by various precision electronic navigation systems (e.g., LORAN C piloting display) under a variety of operational conditions.

It should again be noted that while training in port-specific geographic data base may be desired, it is not required for effective training of these skills. The experimental CAORF training program, which included Advanced Instrumentation training, successfully employed a generic data base.

2.4.6 Restricted Water Navigation (Apprentice Pilots)

Shiphandling/ship bridge simulators may also be appropriate for training apprentice pilots specific navigation skills. The presence or absence of previous experience by the apprentices, however, may affect the type of simulation required. If they do not have previous at-sea experience, the acquisition of restricted water navigation skills via simulator training within a generic port data base may be acceptable. If they do have previous at-sea experience (e.g., former deck officers), then such simulator-based training would probably have to occur within an appropriate port-specific data base. This would add substantially to the cost of the training as discussed in Paragraph 2.3, thus making the acquisition of such skills via simulator less attractive. Examples

of the behavioral content of representative training objectives for this area of pilot simulator training may include:

- Effectively employ appropriate dead-reckoning techniques under a variety of operational conditions.
- Effectively employ appropriate visual position-fixing techniques when employing various charted and uncharted aids to navigation under a variety of operational conditions.
- Effectively employ appropriate radar navigation techniques under a variety of operational conditions.
- Effectively employ appropriate depth soundings under a variety of operational conditions.
- Effectively employ appropriate electronic navigation systems (e.g., LORAN C) under a variety of operational conditions.
- Effectively integrate navigation information from multiple sources to determine and monitor ownship position during a transit under a variety of operational conditions.

2.4.7 Rules of the Road (Apprentice Pilots)

The application of rules-of-the-road is another area in which simulator-based training for pilots may be desirable. This training would probably be most applicable for apprentice pilots. Application of the Inland Rules and the International Rules could probably be satisfactorily accomplished within a generic port data base. However, application of these rules in light of local traffic conditions and customs would obviously require an appropriate port-specific data base. Examples of the behavioral content of representative training objectives include:

- Demonstrate proficiency in the application of the appropriate rules-of-the-road when in a meeting situation under a variety of operational conditions.
- Demonstrate proficiency in the application of the appropriate rules-of-the-road when in a crossing situation under a variety of operational conditions.
- Demonstrate proficiency in the application of the appropriate rules-of-the-road when in an overtaking situation under a variety of operational conditions.
- Demonstrate proficiency in the application of appropriate rules-of-the-road when in "special circumstances" under a variety of operational conditions.

2.4.8 Vessel-to-Vessel Communications (Apprentice Pilots)

The proper procedures and effective utilization of vessel-to-vessel communications is another skill area in which simulators appear to have potential for apprentice pilots. Obviously, the final adaptation of vessel-to-vessel communications procedures to a particular locale should be accomplished at-sea in the specific pilotage area. However, simulator training may be appropriate for the initial acquisition of basic skills such as proper use of the radiotelephone in order to ensure a solid foundation for these important skills. This may be particularly true for those apprentices who have not had previous at-sea experience. Examples of the behavioral content of representative training objectives include:

- Demonstrate proficiency in the use of the ship whistle for maneuvering and warning signals under a variety of operational situations.

- Demonstrate proficiency in the proper monitoring of the required VHF communications frequencies under a variety of operational situations.

- Demonstrate proficiency in the proper use of VHF communications for collision avoidance in a variety of operational situations.

- Demonstrate proficiency in the proper use of VHF communications for vessel traffic services in a variety of operational situations.

2.4.9 Advanced Vessel-to-Vessel Communications (Experienced Pilots)

A review of a number of accident analyses indicate that vessel-to-vessel communications while not a probable cause of restricted water accidents have been identified as a contributing cause of many accidents. As a result, it may be prudent for pilot associations to consider additional training in this skill area for their members. During the experimental training program at CAORF, there were indications that benefits may be obtained, not from additional radiotelephone procedural training, but rather appropriate instruction in the art of affirmative communications. The efficient and effective exchange of relevant information, particularly intended vessel actions, is important in order to minimize distractions and focus the pilot's attention on the shiphandling problem at hand. Sample training objectives for this area of training may include:

- Demonstrate proficiency in the exchange of relevant information on the status and intended actions of ownship and another vessel, which is preparing to depart its berth or anchorage.

- Demonstrate proficiency in the exchange of relevant information on the status and intended actions of ownship and another vessel, which are projected to meet or overtake each other in an inappropriate section of the channel.

- Demonstrate proficiency in the exchange of relevant information on the intended actions of ownship and another vessel in a variety of extremis situations.

2.4.10 Restricted Waters Decision-making (All Pilot Levels)

Discussions with many pilots have indicated the importance of being able to rapidly respond to a variety of unanticipated problems, such as a vessel unexpectedly departing from an anchorage and crossing ownship's bow. Often, sufficient time remains for the pilot to avoid an emergency situation ... if he takes appropriate action at an early time. These types of situations involve early detection of a problem, rapid assessment of the situation and alternative actions available, selection of a course of action, and effective implementation. This skill area appears very desirable for apprentices and limited experienced pilots since it apparently takes many years of experience to develop these skills for the wide range of situations that can be encountered within any pilotage area. Simulator training may be an appropriate vehicle for (a) acquiring such skills without high risk or (b) reducing the amount of time required to attain the desired exposure to a variety of selected operational problems. Refresher training for experienced pilots as

regards these skills may also be appropriate, particularly in troublesome channel areas that are infrequently transited.

If a geographic data base of the trainees own pilotage area is not employed, then extreme care should be exercised that the "selected operational exercises" be similar to situations found within his pilotage area. This will ensure maximum interest and motivation by the trainees during training and also improve the potential transferability of the acquired skills.

- Effectively respond to an unanticipated vessel departing from an anchorage within a confined channel under various operational conditions.
- Effectively respond to an unanticipated vessel departing from a berth within a confined channel under various operational conditions.
- Effectively respond to an unanticipated delay in the opening of a drawbridge under various operational conditions.
- Effectively respond to a loss or degradation of propulsion power within confined channels under various operational conditions.

It should be noted that the emphasis of this training module is on the early detection of a problem, the rapid identification/evaluation of alternative solutions, and the selection of the appropriate shiphandling action. The emphasis is <u>not</u> envisioned to be on shiphandling principles, although the proper application of shiphandling principles would be critical in this module. It is recommended that the trainees have a solid foundation of shiphandling skills prior to enrolling in this type of training. Successful completion of the previously noted shiphandling and emergency shiphandling training modules may be an appropriate prerequisite for this training.

CHAPTER 3

CRITICAL TRAINING SYSTEM CHARACTERISTICS

3.1 DESCRIPTION OF THE SIMULATOR TRAINING SYSTEM

A simulator, such as the radar simulator or the shiphandling/ship bridge simulator, is a device that duplicates limited aspects of the real world. The aspects of the real world necessary for duplication depend on the objectives of the training system, specifically the nature of the skills to be acquired or the types of tasks to be performed. If only radar-related tasks are of interest, then effective training may be accomplished via a radar simulator, which duplicates the hardware/control aspects of the radar system as well as the visual imagery of the radar display. However, for the majority of shiphandling tasks, which involve visual cues external to ownship and a bridge environment within which several individuals can interact, a considerably more sophisticated shiphandling/ship bridge simulator is required. Although of greater sophistication and complexity, this simulator is also limited with regard to the aspects of the real world that it can duplicate.

From a training standpoint, the simulator enables the practice of tasks, which may lead to the improvement of skills. Practice is one important element of the training process. However, other important elements of the training process also exist, such as providing feedback to the trainee regarding the outcome of his actions. The training system is more than just a simulator; it does more than provide a setting for the practice of tasks. It should be designed specifically to enhance the training process. The complex simulator-based training system should be viewed as being comprised of three major elements as outlined in Figure 2: (1) the simulator design, (2) the training program structure, and (3) the instructor qualifications.

Traditionally, the emphasis has been on the design of the simulator, that is, the real world fidelity characteristics of the training device. Recent research has indicated that the techniques employed by the instructor and the structure of the training program are as critical to an effective simulator-based training program as the fidelity of the simulator. It is important that the designers, operators, and users of simulator-based training become aware of the substantial impact that the non-simulator elements of the training system have on the effectiveness of the training process.

This section of the report analyzes and discusses in detail each of the major elements of a simulator-based training system. The critical characteristics within each major element are identified and appropriate guidance is provided to assist individuals interested in the design and evaluation of a simulator-based training system for pilots.

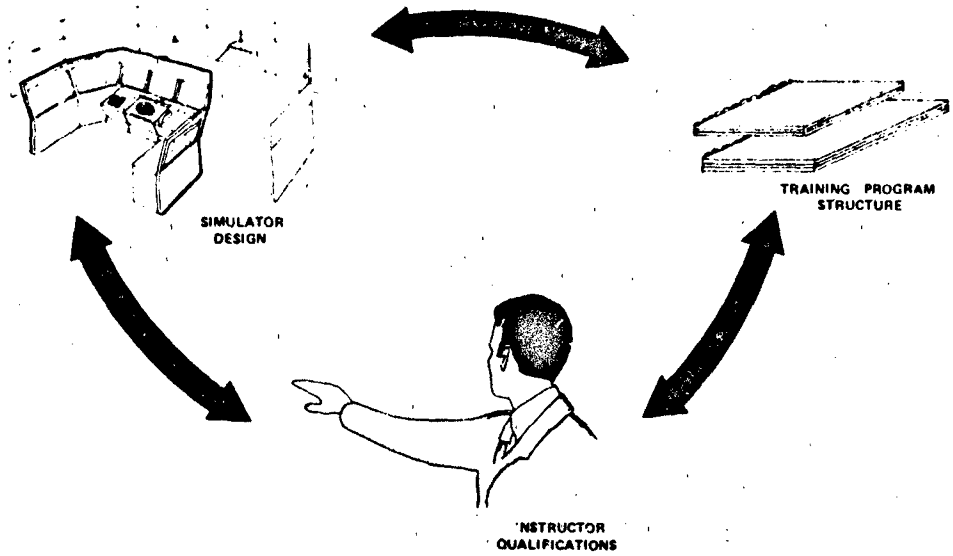

Figure 2. Major Elements of Simulator-based Training System

3.2 SIMULATOR DESIGN

As previously noted, a simulator is a device that duplicates limited aspects of the real world. Not all aspects of the at-sea bridge environment need to be duplicated, just those aspects which impact the performance of the shiphandling tasks being addressed. The following are the critical characteristics of a shiphandling/ship bridge simulator for which appropriate guidance is contained herein:

- Visual scene
  - Geographic area
  - Horizontal field-of-view
  - Vertical field-of-view
  - Time of day
  - Color visual scene
  - Visual scene quality
- Radar presentation
- Bridge configuration
- Ownship characteristics and dynamics
- Exercise control
- Traffic vessel control
- Training assistance technology
- Availability

When designing or evaluating a simulator-based training system for pilots, it is important that appropriate consideration is given to each of these critical characteristics as outlined in this report. However, particular emphasis should be placed on the quality of ownship characteristics and dynamics (see Paragraph 3.2.4). This is an area that must be beyond reproach in order to ensure that the simulator is accepted by pilots as a valid training device.

3.2.1 Visual Scene

This is the characteristic of a simulator that provides the trainee with the visual conditions of a scenario external to ownship's pilothouse (e.g., buoys, other ships, etc.). It is usually the most expensive element of a shiphandling simulator. Numerous optical and engineering techniques are available to generate a visual scene.

These include projection of point light sources, shadow graphs, model boards, filmstrips, and computer-generated graphics. The complexity and accuracy contained in a visual scene relate very closely with total simulator cost. Mariners tend to want high fidelity visual scenes for realism. Research has indicated that a very high level of fidelity is usually not required in the visual scene to effectively train the development of many shiphandling/navigation skills, although in some cases a high level of fidelity may be required. A careful analysis of the objectives to be accomplished and the associated requirements for visual cues will provide valuable insight into the identification of a satisfactory visual scene for minimum cost. The following discussion outlines several important considerations in the design or evaluation of a shiphandling simulator's visual scene.

Geographic Area

The type of geographic area selected should depend on the types of scenarios needed to train the specific skills required to achieve the program training objectives. The proximity to land of the scenario gaming areas heavily impacts the design of the simulator's visual scene. Generally speaking, the closer the scenarios are to land the greater the investment required to provide a quality visual scene. This appears to be true with all the present visual scene generating technologies, from point light sources to computer-generated graphics. In addition, if the training objectives require the use of a port-specific data base in lieu of a generic data base, the fidelity requirements of the training system may be impacted. Four alternate geographic areas are specified below:

Level I: No Land Mass. These dat bases employ scenarios in which lar is not visible in the visual scene. limited number of traffic vessels ar buoys may be utilized to configur training exercises for a selecte training objective. For example stopping and turning a large vesse around within a confined channel ma require only the buoyed channel in th visual scene. Water depth, current and wind should, of course, be set a appropriate for training. It shoul be noted that this is a minimum visua scene for the acquisition of a limite number of piloting skills. The ke requirement is that sufficient visua cues are present with the traffic ves sels and buoys to conduct the desire training effectively.

Level II: Coastal. These dat bases employ scenarios in which dis tant land, including prominent geo graphic features such as lighthouses is available in the visual scene alon with the buoyed channels and limite number of traffic ships discusse above under Level I: No Land Mass. corresponding radar presentation an water depth data base may also b utilized as required by specifi training objectives. This level woul be the minimum level for skill requiring visual information fror land-based objects for determining o assisting in the determination of the geographic position of ownship. I would not suffice where additiona navigation cues or scenario realism (e.g., traffic ship backing from berth) requires a greater proximity to land. It should be noted that the Dutch successfully train selected emergency shiphandling and advanced instrumentation training objectives with a simulator that does not have the capability of presenting land mass close aboard in the visual scene. "Close aboard" is used here to

describe the presence of visible land at distances of less than 1.0 nm from ownship.

Level III: Restricted Waters-Generic. These data bases employ scenarios in which land mass and several traffic ships are present close aboard. A complex environmental data base utilizing water depth, wind, and current may also be utilized as required for specific training objectives. This level of geographic area would normally be required for the more sophisticated pilot training objectives. It would suffice for all pilot training objectives except those requiring a port-specific setting. It should also be noted here that an effective means of simulating reduced visibility (i.e., fog) is desirable, when involved with restricted waters scenarios, since it has been found to be a valuable technique for adjusting the difficulty level of many training scenarios.

Level IV: Restricted Waters - Port-Specific. These data bases involve the replication of selected areas within a particular waterway. It is anticipated that, although desirable, they will be required only for special pilot training requirements. This level would not necessarily require a greater simulator design capability than for the Restricted Waters - Generic level. The principle economic drawback of port-specific data bases, as previously noted, is the development cost for separate data bases for each port area. It should also be noted that additional resources, beyond those required for a generic data base, may be required to accurately produce and maintain a satisfactory port-specific visual scene. This is due to the greater level of fidelity required for such items as the positioning of critical cues, the intensity of navigational lights, the degree of background lighting interference, etc.

Horizontal Field-of-View

The horizontal field of view required for a shiphandling/ship bridge simulator should depend on the specific objectives of the training program. If the visual cues required to execute a particular shiphandling maneuver are within a relatively narrow field of view, such as when training apprentice pilots the skill of utilizing range lights, a reduced field of view is satisfactory and may even be preferable since it artificially focuses the trainee's attention on the required visual cues. However, prudent training practice would indicate that the student should then be trained in utilizing this skill under conditions with operational noise and distractions; for example, identifying the range lights and concentrating on them among the background lights and distracting traffic vessel movement. This type of training could then imply a requirement for greater horizontal field of view than that identified for the development of the basic skill. Consideration should also be given to the utilization of a variable horizontal field of view in order to gain the training leverage discussed above.

The cost of a shiphandling/ship bridge simulator increases as the horizontal field of view increases. This increase in cost results not only from increased projection equipment costs but also from increased processing hardware and software costs. Utilizing simulators with higher initial cost may result in increased training costs for pilot associations as the training facility attempts to generate an acceptable rate-of-return on it investment.

Level I: Greater than 90^{o}, less than 120^{o}. Use of this horizontal field of view may be satisfactory for training a limited number of specific shiphandling skills (e.g., range lights, buoyed channels). It may also be satisfactory for training the application of the rules of the road in meeting and fine crossing situations. However, if it is employed in broader crossing situations or overtaking situations where visual contact is lost with the traffic vessel, there may be a danger that the trainees will have a tendency to neglect visual information and rely heavily on radar in these types of scenarios. A horizontal field of view of less than 120 degrees is generally unacceptable for training skills that involve visual position fixing since adequate horizontal angular separation of suitable geographic points suitable for a visual fix can not be obtained except for possibly a few unique cases. In this same light, such a limited horizontal field of view also precludes the development of skills in the use of turn bearings. There may, however, be some training value for a horizontal field of view of less than 120 degrees in the development of skills involving the integration of visual lines of position with radar information or other electronic navigation information, although the trainee may be inadvertently trained to neglect the more advantageous objects abeam for visual bearings.

Level II: Greater than 120^{o}, less than 240^{o}. Use of this horizontal field of view appears appropriate for the majority of the desired skill categories identified in Chapter 2. It may, however, be limited if visual bearings abaft $\pm$120 degrees relative are important for navigation in a particular port. In addition, it may also constrain the acquisition of skills relating to specific shiphandling tasks, such as overtaking vessels within confined channel where visual information abeam abaft the beam is very critical.

Level III: Greater than 24ʳ Use of a horizontal field of view this magnitude may be appropriate the development of skills involvi the following factors are deemed to important:

- Vessel with pilothouse forwa (i.e., ore carriers)
- Use of rear ranges
- Use of visual bearings abaft $\pm$1 degrees relative (e.g., specif port requirement)

One method of obtaining visual info mation aft without a 360^{o} horizont field-of-view is to utilize a sing screen, or single monitor, on whi selected rear views are presented. this method is employed, care shou be exercised that the acquisition this rear visual information does n significantly impact the shiphandlin navigation tasks normally accomplish at-sea.

It should be noted that many of t visual scene generating technologi have the capability, particularly considered during the initial desig of optically/electronically rotati the fixed visual scene to provi visual cues in areas not normally co sidered possible with that desig For example, Figure 3 illustrates 240^{o} horizontal field of view pr viding a visual scene from 30 degre left of ownship's heading to 30 d grees beyond dead astern. This may particularly desirable during coas wise navigation exercises to facil tate the use of visual bearings, when approaching and picking up tow. This flexibility with the sim

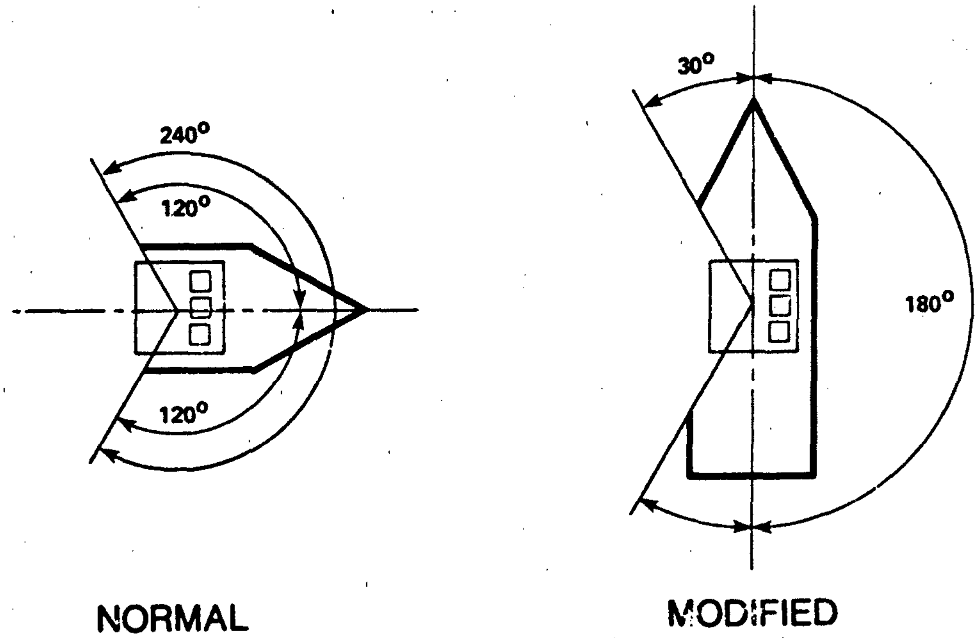

Figure 3. Rotation of Visual Scene

lated visual scene should be used cautiously since it alters the bridge environment's proper orientation with the visual scene (i.e., front of pilothouse faces side of vessel). The impact of this effect on the training provided is unknown. Some facilities have the capability to move the bridge equipment consoles to overcome this effect. In addition, new facilities could be conceivably developed that would allow for the rotation of the pilothouse to overcome this effect.

Vertical Field of View

The vertical field of view required for a shiphandling/ship bridge simulator should depend on the specific objectives of the training program. If the visual scene requirements for the training objectives are at or near the horizon (i.e., distant landmass or traffic vessels), then a relatively narrow vertical field of view would probably suffice. If the visual scene requirements are contained over a larger vertical angular sector (i.e., landmass or traffic vessels close aboard), then a larger vertical field of view is required. Normally, docking exercises when ownship is being brought into a berth require the maximum capability of vertical field of view. Generally speaking, the greater the vertical field of view the greater the cost. Since relatively small increments of vertical field of view can substantially improve a simulator's capability, this is not a high cost characteristic as compared to horizontal field of view.

Level I: $+5^{\circ}$ to $+10^{\circ}$. This vertical field of view may be accept-

able for distant land and traffic vessels. Caution should be exercised in utilizing a narrow vertical field of view, particularly under daytime conditions because the fidelity of the simulation is reduced considerably when a daytime scene is bounded top and bottom with large dark bands. This is due to the projected image not filling the vertical field of view normal observed from the pilothouse. Consideration should also be given to the amount of ownship bow required in the visual scene when attempting reductions in vertical field of view. As the vertical field of view becomes narrower, a smaller and smaller portion of ownship's bow can be observed. This may present a problem for specific ships within specific scenarios where the relationship of the bow to other objects (e.g., buoys) provides a visual cue normally used in the piloting process.

Level II: +10° to +15°. This vertical field of view would be acceptable for distant land and traffic vessels. It would also be acceptable for land relatively close aboard, and it may be acceptable for traffic vessels close aboard depending on several factors, including the height of eye of ownship. This vertical field of view would normally present a sufficient bow image to overcome the difficulties noted under Level I above.

Level III: Greater than +15°. This vertic . field of view would generally be acceptable for land and traffic vessels both at a distance and close aboard. This type of vertical field of view would probably be required for docking exercises. The vertical field of view requirement for docking exercises are usually driven by the height of eye on ownship.

With regard to vertical field of view, two additional points should be noted. First, it is not possible to realistically present objects in the visual scene which are closer than the distance from the preferred viewing point (i.e., focal point) to the screen. This is usually not a problem when simulating large vessels with beams in excess of 100 feet. However, when simulating smaller vessels (e.g., tugboats), the reader is reminded it is not possible to accurately simulate a buoy which passes 20 feet abeam from the preferred viewing point if the visual scene screen on which it is to be projected is 30 feet away.

Second, the vertical field of view can be optically manipulated to a certain degree to better view objects which are low in the visual scene such as buoys or docks which are close aboard. This can be accomplished by (a) artificially lowering the height of eye or (b) artificially rotating the visible sector down in order to project these lower objects within the scene. Once again caution should be utilized since the impact of such modifications on the effectiveness of training is unknown.

Time of Day

The ambient lighting conditions under which simulator-based training is accomplished is another critical simulator design characteristic. Some members of the maritime community have advanced the theory that only nighttime simulator-based training is required since it is the more difficult operational situation. Research from earlier CAORF experiments, however, has indicated that simulator-based training should be conducted under the same ambient lighting conditions as the operational tasks. Nighttime shiphandling may be more difficult than daytime shiphandling, but training under daytime conditions prepares the shiphandler for daytime operations

better than training under nighttime conditions. One would naturally expect the complement to be true; that nighttime training prepares one for nighttime operations best. Since it would appear to be prudent to train shiphandlers for most operations under both day and night conditions, a training facility that offers a comprehensive simulator-based training program should have a simulator with a day/night capability. However, economic or logistic constraints may allow training only the most critical skills under both day and night conditions. If this is the case, it would then appear desirable to train the remaining skills under the more difficult lighting condition, which would usually be the nighttime condition.

Level I: Night-Only. Beneficial training in a number of training categories, such as Advanced Instrumentation, Vessel-to-Vessel, Communications, Rules of the Road, etc., may be accomplished using a night-only visual scene. However, caution should be exercised as regards the effect of such training on daytime operations. For example, experience has indicated that mariners have a tendency to neglect radar information, visual bearings and VHF communications more during daylight operations (when they have good visual contact) than under nighttime conditions. Training under nighttime conditions only, would not detect or correct such tendencies, and could give a false sense of trainee proficiency.

Very little information is available on the benefits associated with various levels of the night visual scene (i.e., point light sources versus silhouettes with lights). The only guideline presented here is that silhouettes do provide visual cue information and should be utilized in those scenarios where they are deemed important for training. As a result, simulators with a nighttime visual scene that is generated by point light sources may not be satisfactory for some specific training objectives.

It should also be noted at this point that the German pilots have been successfully employing the point light presentation (without silhouettes), which is located at the Bremen Nautical School, for a number of years. This training, of course, involves skills that can be addressed using only the visual information presented by the spotlights. Such skills involve instrument sailing, specific emergency scenarios, and pilotage within their own particular geographic area in which they have considerable at-sea experience. The latter gives rise to an interesting point. Discussions with several U.S. pilots have indicated an ability to recognize and accept a simulation of their own port from a limited number of key visual cues. In other words, during the piloting process, these individuals can either ignore or mentally fill in a number of missing, non-critical port characteristics. However, caution should be exercised since this may not be true for all pilots, particularly if they lack the proper motivation for the training.

Level II: Day-Only. Beneficial training in nearly all of the training categories may be accomplished using a day-only visual scene. As previously discussed, and intuitively realized by most people, such daytime training would not thoroughly prepare the pilot for nighttime operations. However, it may be satisfactory to utilize a day-only visual scene for specific shiphandling and emergency shiphandling training objectives, in which the shiphandler would not expect to operate his vessel at night. For example, a particular company or a particular

port may restrict the arrival or departure of a certain size or type of vessel (e.g., LNG) to daylight hours.

Level III: Day/Night. This level of the time of day visual scene characteristic appears to be the most desirable for a simulator-based training facility which offers or plans to offer a comprehensive training program. With such flexibility designed into the simulator, scenarios under both day and night conditions can be provided within the training program as appropriate. A note of caution, however, is warranted. Since the visual scene generating and projecting hardware (and software in some systems) must have the capability for both daytime and nighttime presentation, the quality of either or both presentations may suffer as a result of tradeoffs made in the design process. The quality of the visual scene should be evaluated in accordance with the guidelines set forth under "Visual Scene Quality."

Finally, if a geographic data base other than the pilots' own port is employed, it would appear to be desirable to conduct at least the familiarization exercises and the initial training exercises under daylight conditions. This would allow the pilot additional time to become acclimated prior to navigating within a strange port at night. If a pilot is thrust into a strange port at night without proper acclimation, he may direct a substantial portion of his energies towards secondary navigation tasks in lieu of focusing on the desired training objectives.

Color Visual Scene

The requirement for color in the visual scene of a shiphandling/ship bridge simulator is also related to the training objectives to be accomplished via the simulator-based training. Research appears to indicate that a color visual scene may not be required for some training objectives. Guidelines for scenarios in which a black and white visual scene will provide acceptable training are provided below. However, it does appear desirable for a simulator-based training facility which offers or plans to offer a comprehensive training program to have a visual scene capable of simulating color for at least vessel sidelights and aids to navigation -- these being the principal color cues historically used by the maritime community.

Level 1: Black and White. A black and white visual scene may be acceptable for training specific shiphandling training objectives under both day and night conditions. In daytime operations, the black and white presentation downgrades, but may not eliminate any important visual cues. In nighttime operations, all lights become white and the information transmitted by their color characteristic may be provided via an associated flash code. This is not viewed as an insurmountable problem with aids to navigation since it is possible to encounter, in the at-sea environment, geographic areas marked by only white lights with distinctive flash rates. Hence, deck officers and pilots have experience in interpreting and using flash patterns during the navigation process, (although this may limit the application of such a simulator for training in specific ports where color is a key visual cue).

It is generally recognized that the sidelights of traffic vessels must be colored to be realistic. However, it has been shown that mariners can be successfully trained under conditions where they must process the flash rate of a light over time in lieu of in-

stantaneously obtaining the red color of a port sidelight, if a relatively light amount of traffic is encountered in the scenarios. It is expected that the trainee's ability to keep track of traffic movement under such conditions will be taxed in scenarios with high contact workload.

Level II: Multi-color. The utilization of multiple color in the visual scene can provide acceptable simulator-based training for all the marine pilot skills identified. Experience has indicated that effective simulator-based training can be conducted without extensive use of color and shading. Caution should be exercised in the use of color and shading in order to add to the realism of the environment and not to introduce color cued distractions. See the following section on "Visual Scene Quality."

Visual Scene Quality

The simulated visual scene should have sufficient quality such that effective training can be conducted for the desired training objectives. Factors such as resolution, luminance, contrast ratio, update rate, etc., should be effectively manipulated during the visual scene design such that the following considerations are satisfied.

- When viewed from or near the preferred viewing point, objects normally viewed from a ship's bridge appear clear and readily recognizable in the proper size and perspective.

- The sensitivity of the visual scene to parallax distortion as the deck officer moves away from the preferred viewing point should not significantly impact his normal positions and movement within the pilothouse during the scenarios envisioned. For example, pilots may have conning positions other than at the center of the pilothouse. In addition, when bridge teams are involved, it is not uncommon to have several individuals evaluating the situations from different locations in the pilothouse. The sensitivity of the visual scene to parallax distortion, as a function of location within the pilothouse, should accommodate such conditions if appropriate.

- The size and perspective of such objects should change as appropriate when motion is introduced into the simulation.

- The motion of objects in the visual scene should appear in a relatively smooth sequence.

- The visual scene should be free from any distracting flicker.

- The visual scene should be free of any visible raster lines.

- The intensity of lights should appear to vary with range.

- Discontinuities between projected images/screens in the visual scene should be minimal.

- Color match between projected images/screens in visual scene should be minimal.

- The intensity and hues of critical color cues (e.g., traffic vessel sidelights) should be acceptable to the experienced mariner.

- The use of color and shading should be such that it adds to the realism of the environment and does not introduce color cued distractions.

- The visual scene should be free

from substantial brightness variations as the trainee moves from the preferred viewing point (i.e., fall-off) within the confines of the pilothouse.

- The resolution of the visual scene should be such that the required visual cues, at a particular range from ownship, are projected. For example, if it is (a) important and (b) normally possible to view traffic vessel masts at 5 nautical miles, then the resolution of the projected image should be such that they are contained in the visual scene when the traffic vessel is at that range.

- The use of auxiliary views of a particular segment of the projected (or unprojected) visual scene should not substantially detract from the realism of the simulated environment or become an operational crutch which would not be available in similar scenarios at-sea. Examples of auxiliary views may include a single CRT display used to provide the mariner with (a) a view aft to assist in periodically checking a vessel being towed or (b) a "binocular effect" on simulators in which the resolution of the visual scene does not permit magnification by binoculars (see discussion below).

The visual scene resolution of many simulators is designed to provide the deck officer with an acceptable visual scene when viewed with the naked eye. If a set of binoculars were to be used by a pilot to look at a traffic ship in order to determine its aspect, the ship would look larger through the binoculars but may not be resolved any better. In other words, if the traffic ship consisted of four units of resolution initially, it would still contain four units of resolution through the binoculars although each unit would appear larger to the eye. Therefore, no additional information is obtained by viewing in this manner. An auxiliary view is one technique for providing the deck officer with the additional information normally available through binoculars.

3.2.2 Radar Presentation

The type of radar equipment required on a shiphandling/ship bridge simulator is related to the objectives of the training program to be accomplished. A sophisticated radar/CAS is generally not required for the majority of the identified pilot training objectives. A full mission shiphandling/ship bridge simulator should not be utilized to develop radar plotting and evaluation skills. This may be more cost effectively accomplished on a part-task radar simulator.

The presence of noise (e.g., sea clutter and false echoes) on the simulated radar presentation may be employed if appropriate for the training objectives. As previously discussed for "Horizontal Field of View", it may be desirable to train skills, such as turning a large vessel around within a confined channel or employing racons to navigate a constant radius turn without distracting noise. The ability to accomplish such tasks under noise conditions may then be assumed, if the trainee has already developed the skill of discriminating traffic vessels, aids to navigation, etc., from other noise on the screen through previous at-sea or radar simulator-based training. It would, however, be desirable to evaluate performance of the desired tasks under noise conditions during the final stages of training.

The simulation of line of sight considerations should be accomplished as

required by the specific training objectives. For example, if masking of traffic vessels by a higher building or hill is important when training the approach to a particular port, it should be adequately included in the simulation. Such line of sight considerations, as well as the previously mentioned noise considerations, may be added to either Level II or Level III as outlined below.

Finally, it should be noted that appropriate procedures should be employed to ensure that the ranges and bearings obtained from the simulated radar presentation correlate satisfactorily with the simulated visual scene presentation, etc. In addition, it should be verified that the accuracy of this correlation between the radar and visual scene information does not vary as a function of either scenario time or distance travelled.

Level I: No Radar. There are a number of marine pilot training objectives, particularly in the shiphandling and emergency shiphandling areas, for which effective training may be accomplished without a radar presentation.

Level II: Low Fidelity Radar. The majority of pilot training objectives may be accomplished using a computer-generated synthetic radar presentation as long as the required radar or CAS functions are available. Care should be exercised that the necessary radar information and the tasks associated with obtaining that information during a simulator exercise are compatible with the information available and the tasks performed at sea.

Level III: High Fidelity Radar. This level of radar presentation would include the use of actual radar or collision avoidance hardware that are appropriately interfaced with the remaining simulation systems. Although desirable, such high fidelity is generally not required for the training objectives normally taught at the marine pilot level. However, there may be times when it would be necessary to have such radar systems. For example, when providing vessel specific training it may be desirable to have the specific radar/CAS on the simulator that the actual vessel has on its bridge, if the radar/CAS has a particularly unusual presentation or method of operation.

3.2.3 Bridge Configuration

The physical characteristics of the simulated bridge and the hardware located on same may be related to the specific training objectives to be accomplished. However, experience has indicated that this may not be critical as long as some minimum level of fidelity in the bridge environment is maintained. The size of the pilothouse, the type of equipment available, and the arrangement of this equipment should have a high degree of compatibility with that found on similar vessels at sea in order to minimize the introduction of any extraneous factors into the training process. The replication of the pilothouse of a particular vessel generally is not warranted except possibly when providing shiphandling/navigation training for a specific vessel type. It is anticipated that the majority of pilots, particularly experienced pilots, have considerable adaptability to a variety of bridge configurations. The design of any shiphandling/ship bridge simulator should consider the inclusion of a high degree of fidelity since the bridge configuration is a relatively small proportion of the total simulator cost, it is cheap insurance to protect against any irregular behavior that may be associated with the simulated

pilothouse environment. In addition, the student's confidence in the simulator as a training device and hence his motivation during the training program may be detrimentally affected if the simulated pilothouse environment does not meet his minimum expectations.

Level I: Reduced Bridge. A pilothouse that is substantially reduced in size and contains only the essential equipment necessary for the specific training to be accomplished. This bridge configuration may be of value in training a limited number of skills. Caution, however, should be exercised that any spatial or equipment alterations do not significantly impact the shiphandling/navigation tasks to be accomplished.

Level II: Full Bridge. A pilothouse that is full size, or nearly full size and contains all or the majority of bridge hardware normally found on similar vessels at sea. This bridge configuration is recommended for simulators that are involved with training senior mariners for the majority of the identified desired skills categories.

Level III: Replication Bridge. A pilothouse that is an exact copy of the pilothouse of a specific vessel as regards both equipment and layout. This level of fidelity is generally not required for pilot training. However, it may be desirable to provide such a high level of fidelity when training pilots to handle a specific vessel type that may have particularly unusual bridge equipment or layout.

3.2.4 Ownship Characteristics and Dynamics

The maneuvering response of ownship under various environmental conditions is another critical characteristic of a shiphandling/ship bridge simulator for training pilots. In fact, it may be one of the most critical characteristics. Pilots generally handle ships in shallow, restricted waters where the margin for error is small. Therefore, it is extremely important for effective pilot training that the simulated vessel handle like a real vessel.

The development of hydrodynamic response models involves a complex process. The resultant models may have several different levels of sophistication. The required sophistication of a model is related to the specific skills to be developed within the given training program. If a specific effect, such as bank, bottom, passing ship, etc., is not involved in the training, it need not be included in the model. The identification and content of three levels of ownship characteristics and dynamics are discussed below.

Level I: Shallow Water. This level of the hydrodynamic model includes the vessel's deep water response characteristics plus the appropriate shallow water modifications. It should likewise include the water depth data base for the particular geographic areas involved during the training. Wind and current effects should also be provided. A spatial dependent current data base may be employed, particularly when modeling a specific port area in order to simulate the fact that current magnitude and direction vary with the geographic position of ownship. The capability of reversing engines to decelerate more rapidly (but no astern motion) should also be included. In addition, low speed hydrodynamic modifications may be appropriate in order to accurately simulate forward velocities of less than two (2) knots. This level of ownship

characteristics and dynamics would be acceptable for a number of the identified pilot skill areas. It would not be sufficient for the more advanced shiphandling training, such as anchoring, utilizing tugs, or compensating for bank effects.

Level II: External Forces. This level of the hydrodynamic model involves the capabilities for Level I, plus anchor forces, tug forces, bow thruster forces and pier/dolphin forces as required for training. It would be acceptable for the majority of pilot training objectives. It would not be acceptable for shiphandling skills involving the more sophisticated hydrodynamic effects, such as bank effects or passing ship effects. In addition, it would be inadequate for evolutions that require astern motion.

Level III: Complex Hydrodynamics. This level of the hydrodynamic model involves the capabilities indicated above for Level II, plus appropriate bank effects, passing ship effects, kick effects, squat, and reverse motion capability. This level of own-ship characteristics and dynamics would be recommended for the more advanced shiphandling training, such as compensating for bank effects and the majority of anchoring/docking evolutions.

Pilots and pilot associations interested in employing simulator training should carefully scrutinize the vessel characteristics and dynamics available at a given facility as regards their specific training requirements. Experience has shown that the acceptability of vessel hydrodynamic response is a critical element for the effective simulator training of pilots. The attainment of this acceptability is an evolutionary process as observed by the Dutch during the development of their simulator training program for pilots. U.S. pilots and U.S. simulator training facilities should anticipate a similar process. Pilots and pilot associations should work with training facilities that appear to have potential to fulfill their requirements in order to refine the accuracy of their simulations.

Commercial simulator-based training facilities should have prudent procedures to ensure the accuracy of their hydrodynamic simulation models and coefficients. Such procedures should include both analytical evaluations (i.e., turning circles, advance and transfer trajectories) and subjective evaluations by experienced mariners for all load and environmental conditions anticipated. The interested reader should also contact the following organizations for their latest publications on this subject:

The Computer Aided Operations Research Facility (CAORF)
National Maritime Research Center
Kings Point, New York 11024

The Society of Naval Architects and Marine Engineers (SNAME)
One World Trade Center, Suite 1369
New York, New York 10048

Similar precautions should also be taken to ensure the accuracy of the geographic/environmental data bases when modeling a specific port.

Finally, it should be noted that different engine response models are available for various steam, diesel, and gas turbine propulsion plants. Generally, such modeling sophistication is not required for training the majority of pilot shiphandling skills. However, if it is important for the skills being taught, the appropriate engine response model should be employed.

3.2.5 Exercise Control

This simulator characteristic refers to the amount of control that the instructor has over the exercises; their selection, their modification, etc. Although it is appropriate to design such flexibility into a shiphandling/ship bridge simulator to assist the instructor in maximizing the training benefit to be received, caution should be exercised in that too much instructor latitude, particularly by marginal instructors, may reduce, not increase, the training benefits associated with such design capabilities. This may result in negating the resources expended in the development of a well-structured training program with carefully conceived scenarios. Three levels of exercise control that may be appropriate for a shiphandling/navigation simulator are identified and described below.

Level I: Exercise Selection. At this level the instructor's console is limited to the initial exercise selection. The geometry, complexity, and duration of the exercise is fixed by the preset program of the particular scenario selected. Wind, current, water depth, traffic motion, etc., are constrained by the program. If the instructor wishes to change the scenario, the scenario must be stopped and an alternative scenario selected. This constrains the instructor to use only those particular scenarios within the training program, and may limit his adaptation of the training program to the specific needs of the trainees. This may not be a problem if the training program is well-designed and the scenarios are well-conceived to assist in the development of trainee skills. In fact, a well-designed training program should consider the inclusion of additional scenarios to allow for such flexibility during implementation.

Level II: Instructor Pre-Programmed Exercise Control. This level of exercise control contains all the capabilities described above under Level I, plus the capability for the instructor to modify scenarios during initial set-up. Depending on student performance on the previous exercise, the instructor may want to alter the next scheduled scenario by modifying wind or current. He may also want to change traffic vessel positioning, course, speed, or maneuver point. This level of exercise control appears to be appropriate for a majority of the pilots training objectives. The danger associated with marginal instructors tinkering with a well-designed training program as previously mentioned should be noted.

Level III: Instructor Exercise Control. This level of exercise control contains all the capabilities described above under Level II, plus the capability for the instructor to modify the scenario while it is running. This allows the instructor maximum flexibility in adapting the scenario to the students training needs. However, it also provides him with maximum capability of bypassing the predetermined training program and to commence "shooting from the hip."

The capability of altering scenario time, such as freezing the scenario or advancing the scenario in fast time warrants discussion under this simulation characteristic. Generally speaking, the alteration of scenario time is not recommended as part of the training process. A "scenario freeze" capability may be beneficial if used judiciously. A "fast-time" capability is usually not desirable even for demonstration purposes since a danger

exists that the trainee's sense of time may be distorted as a result of observing the visual scene in an accelerated mode. Graphic classroom feedback displays, however, which utilize fast time models can be an effective means of critiquing a scenario (See Training Assistance Technology). While alteration of scenario time on the simulator is not recommended as part of the training process, it may be a desirable feature for scenario or data base development in order to minimize the time required to checkout the simulator exercises prior to training.

Some training facilities have found that a play-back capability may be advantageous to return the simulated ownship to a critical time/geographic point within the previous scenario in order to demonstrate the effect of an alternate control action. If this capability is utilized with a fast-time option as a means of quickly returning to the desired time/geographic point, the cautions cited above, concerning alterations in scenario time, should be considered.

3.2.6 Traffic Vessel Control

This characteristic refers to the amount of control that the instructor has over the selection (i.e., vessel type and size), position, courses, and speeds of traffic vessels in a given scenario. This characteristic may be considered by some to be a subset of the "Exercise Control" characteristic. However, due to its importance with regard to traffic vessel simulation, it is discussed separately here. Four alternative levels of traffic vessel control that may be appropriate for a shiphandling/ship bridge simulator are identified and described below.

Level I: Canned Traffic. This level refers to traffic vessel control in which the traffic vessel has a limited number of tracks that it can follow and cannot, at any time during the scenario, deviate from the track that the instructor selects no matter what course and speed changes ownship makes. The use of canned traffic may result in the development of somewhat unrealistic scenario situations in that the traffic vessels do not respond to ownship maneuvers as does traffic in the real world. This type of traffic control may be best suited for training skills that involve scenarios in which ownship does not interact with the traffic vessels. In other words, the traffic vessels are used primarily as distractions (i. e., noise).

Level II: Pre-Programmed Traffic. This level refers to traffic vessel control in which the instructor can alter to any track the traffic vessel motions during initial set-up to compensate for the tendency of the students in the earlier scenarios. This level of control allows greater flexibility to the instructor than the canned traffic capability. The research to date appears to indicate that there may be a danger that the use of canned traffic vessels during training for situations in which ownship interacts with traffic vessels, may provide the mariner with a false sense of confidence in predicting the behavior of the other vessel. As a result, the training program and the instructor use of this capability should be such as to instill in the students an appreciation of the irregular traffic vessel behavior that is sometimes encountered at sea.

Level III: Independently Maneuverable Traffic. This level of traffic vessel control provides the instructor

with complete control over the actions of the traffic vessels regarding changes in course and speed at any time during the scenario as well as alterations to initial position, course, and speed. The instructor is not limited to a few tracks or a limited number of preprogrammed scenarios. Independently maneuverable traffic allows the instructor to modify scenario complexity and difficulty based on the events as they unfold within the scenario. This level of traffic vessel control is required for many of the vessel-to-vessel communications training objectives and some of the advanced shiphandling training objectives (e.g., passing ship effects). As previously discussed, caution should be exercised in providing marginal instructors with the capability of bypassing a structured training program. The results may be more confusing than helpful.

Level IV: Interactive Bridges. The use of two (or more) simulated ownships each controlled from its own pilothouse, interacting in the same gaming area, is another technique for controlling traffic vessels during a training exercise. The principal advantages of this technique include (a) a high level of realism to the situation involving the interaction between vessels since a wide range of behavior may be expected from those individuals conning each of the vessels and (b) the additional platforms for hands-on training. The principal disadvantages appear to be the high cost of the additional simulators and a reduction of training control in particular training exercises unless the instructor is conning or closely supervising the maneuvers of one vessel. Each training exercise should have a specific objective and should <u>not</u> be viewed as simply allowing the trainee to attain additional experience, except possibly during the latter stages of training.

3.2.7 Training Assistance Technology

In this context Training Assistance Technology refers to the use of computer processing and display capabilities to enhance the training process by assisting the instructor and trainees to comprehensively analyze the simulator training exercises. Research has indicated that this additional capability to more comprehensively analyze trainee performance, if done properly, may promote more rapid understanding of the desired shiphandling/navigation concepts. As a result, the training facility may (1) reduce the training time required to attain the desired proficiency levels, (2) increase the throughput of students, or (3) reduce the instructional staff requirements. However, caution should be exercised in the use of training assistance technology because improper design or use of this capability may detract from the training process, <u>not</u> enhance it. Training assistance technology should be designed by individuals knowledgeable in the use of this potentially powerful capability. Instructors should also be provided with adequate training in the use of training assistance technology for training shiphandling/navigation skills. Four levels of increasingly sophisticated training assistance technology are identified and discussed below.

Level I: Remote Monitoring. The capability for students not training on the simulator to view the simulator exercises remotely (i.e., from classroom) has some distinct advantages for training: (1) it allows the instructor and observing students to discuss the scenario as it unfolds without disturbing those students participating directly in the exercise, (2) it allows the instructor and observing students access to additional information on key parameters not normally

available on the bridge (i.e., distance from channel centerline, current magnitude and direction), (3) it allows the instructor and observing students to better simulate vessel-to-vessel communications, etc., and (4) it allows class size to be increased without causing crowding in the pilothouse. Remote monitoring has the disadvantage for some training objectives of removing the student from the simulated environment where he has the opportunity to develop potentially important perceptual skills (i.e., estimating the distance from channel centerline or side-slip velocity of ownship using a pair of range lights). For most pilot training, it is desirable for all trainees to be located in the pilothouse. However, when an interactive capability is required, such as during training that emphasizes vessel-to-vessel communications, it may be appropriate for the off-watch pilots to be located at the remote monitoring station.

Level II: Feedback Display. The use of computer-generated graphic displays, primarily in the classroom, to evaluate the history of key scenario variables (i.e., distance to turn, rudder angle, yaw rate) using appropriate plots, graphs, and listings can also be extremely valuable for training. Trackplots of ownship's center of gravity or swept path in relationship to other vessels or geographic hazards usually provide invaluable immediate feedback on the performance of the trainees above/beyond simple knowledge of CPA. Such feedback displays assist the instructor in explaining not only <u>what</u> happened but <u>why</u> it happened. This type of feedback appears to be of the greatest benefit when it is supplied immediately after each scenario. The feedback display equipment should have the capability of providing the appropriate displays immediately after each scenario. Computer processing limitations, however, may prevent this response. Although feedback displays can be added to a simulator after its construction, it is best to consider the flexibility for such an addition during the initial design of the training system. Finally, the use of color in such feedback displays is an extremely desirable technique to highlight key points within the display. It should be considered by every training facility employing or considering such feedback displays. These feedback displays may be either a CRT display or a large screen display. The CRT display would probably be utilized in the pilothouse while the large screen display would be employed in the classroom. If a feedback display is utilized in the pilothouse, appropriate cautions should be exercised to see that such a display does not become a "crutch" to the shiphandler during the scenario.

Level III: Instructor Alerts/Prompts. The capability of the simulator to provide the instructor with visual or audio cues at key points within a scenario may also be beneficial to effective training. Such cues may include appropriate direction to the instructor on a special instructor display terminal/console. Such direction may take a form similar to the information normally found in a detailed instructor's guide. This capability may reduce the instructor's burden during training and may result in more standardized instruction whenever multiple instructor's are utilized. There may, however, be a danger that the use of Instructor Alerts/Prompts may restrict or distract a well-qualified instructor in the implementation of his normal effective teaching methods, resulting in reduced efficiency for this individual.

Level IV: Training Management Technology. This level involves the computer's capability to store and analyze trainee performance at key points within a training program over a long period of time. Such information may be valuable when evaluating or restructuring a training program. It may assist in identifying the strengths and weaknesses of the trainee population and form a basis for re-designing scenarios or modifying the sequence of scenarios. It may also assist in the refinement of more meaningful performance measures for the scenarios involved. Training Management Technology also has the capability of providing diagnostic information on the performance and reliability of a training facility's instructional staff, which can be useful in assisting instructors to upgrade their training techniques. It should also be noted that while these techniques have definite benefits associated with them, they also involve additional costs which should be carefully considered prior to making the required investment.

3.2.8 Availability

Historically, radar simulator-based training facilities have had few problems with their equipment which impact their training schedule or the quality of the training provided. However, due to the greater complexity of the shiphandling/ship bridge simulator, particularly in the visual scene, experience to date indicates that the reliability of hardware and the time to repair may be more of a potential problem. Reasonable precautions should be taken to ensure that adequate preventative maintenance is provided, sufficient spare parts are on-hand, and properly trained repair personnel are available in order to minimize unscheduled simulator downtime. Standards should be set forth defining acceptable versus unacceptable simulator performance for training. Such standards should be monitored by both the training facility personnel and the cor mer to ensure a quality simulation nvironment for training. If possible, contingency lesson plans and training program schedule flexibility should be available in order to maximize the benefit of the training time should such simulator malfunctions/degradation occur. Guidelines for alternative levels of availability considerations are discussed below. These levels should be considered as broad guidelines only. The specific availability considerations will be determined by the type of hardware employed; particularly in generating and displaying the visual scene. Any simulator-based training facility should have a sufficiently high level of availability such that the quality and quantity of training is not substantially affected.

Level I: Moderate Availability.

- Simulator should be designed using hardware of best commercial construction/manufacture.
- Moderate spare parts inventory for high usage or critical components, in view of experience, or an appropriate reliability analysis should be made.
- Simulator operational staff should have sufficient training to perform routine maintenance and an appropriate level of diagnostic troubleshooting and repair.
- No specially trained repairmen are onsite to maintain or repair critical hardware.
- Few, if any, service contracts are maintained.

- This level of training system availability may be acceptable for an undergraduate program (i.e., cadets) when a simulator course is only a small part of a curriculum and some flexibility is contained in the trainee's schedule.

Level II: **High Availability**

- Characteristics identified for Level I as modified below.
- Simulator hardware should contain an appropriate built-in diagnostic capability.
- Extensive spare parts inventory should be maintained.
- Service contracts should be maintained on most critical components.
- This level of training system availability may be acceptable for training pilots when the training workload is such that some simulator slack time is available for rescheduling.

Level III: **Very High Availability**

- Characteristics identified for Level II as modified below.
- Specially trained repairmen are onsite to maintain or repair critical hardware.
- Service contracts should be maintained on all critical components.
- This level of training system availability may be desirable for training pilots when the training workload is such that little or no simulator slack time is available for rescheduling.

Finally, several points should be made as regards simulator availability. First, simulators are complex training devices. Users such as pilot associations should anticipate a certain amount of downtime. However, this should be minimal since it impacts trainee morale and motivation and hence the benefits to be derived from the training. Second, it should be noted that the higher availability levels normally require (a) greater initial simulator cost and (b) greater maintenance cost. These then impact the cost that a commercial training facility must charge for simulator training. Third, the more complex the simulator, the greater the chances of problems, which could result in training system downtime, unless additional resources are committed to ensure reliability. Therefore, it may behoove pilots and pilot associations, if possible, to utilize a simulator that meets but does not substantially exceed their established training requirements.

3.3 TRAINING PROGRAM STRUCTURE (CRITICAL CHARACTERISTICS)

As previously noted, the structure of the training program should be viewed as a critical element of a simulator-based training system. It is the mechanism for directing the efforts of the students and the instructor towards the accomplishment of the desired training objectives. It is the plan for ensuring that the maximum training benefits are derived from the available simulator time. The training program structure is also helpful to instructors, particularly instructors with limited training experience, providing them with information on proven simulator training concepts for accomplishing particular training objectives. The following are the critical characteristics relating to the structure of a shiphandling/ship bridge simulator training program:

- Skill levels after training
- Skill levels before training
- Training objectives
- Training techniques
  - knowledge of requirements
  - positive guidance
  - adaptive training
  - postproblem critique
- Instructor's guide
- Classroom support material
- Simulator/classroom mix
- Training program duration
- Class size
- Scenario design
- Number of scenarios
- Stress
- Overlearning

3.3.1 Skill Levels After Training

The first step in the design or evaluation of a simulator-based training program is a clear and concise identification of the goals of the training process. The goals of a particular simulator-based training program usually can best be stated in terms of skill levels after training or output behavioral objectives. Chapter 2 discusses a number of piloting skills for which simulator-based training appears advantageous. It is recommended that the skill levels to be achieved as a result of a particular training program should be developed or translated in these terms in order to more easily apply the guidance contained in this document. Three levels of training program goals are envisioned.

Level I: Direct Skill Improvement. These training programs strive towards the development of specific skills such as Emergency Shiphandling or Advanced Instrumentation. The goal of the training program and the structure of the training program is directed towards improvement in the specified skills only.

Level II: Refresher Training. These training programs result in the improvement or refinement of selected skills already possessed by the trainees. The trainees are generally proficient pilots who desire an opportunity to refresh or practice their skills. No single skill area is emphasized in the training program. If during the program a pilot is observed to be deficient in a particular skill area, he should be directed to the appropriate Level I training program.

Level III: Specific Operational Training. These training programs are developed such that a pilot may improve his skills in specific operational applications, usually within his own port-specific data base. Examples of specific operational training may involve the refinement of shiphandling skills required to anchor a large tanker within a geographic area that is (a) new for the vessel size, (b) particularly hazardous, or (c) seldom transited.

3.3.2 Skill Levels Before Training

In designing or evaluating a simulator-based training program, it is important to identify the skills of the trainee prior to training in order to establish the basis upon which the training program will build. A secondary reason for identifying the trainee's skill levels before training is that it will assist in eliminating any unnecessary simulator-based training, thereby minimizing the training cost for the individual student. Skill levels before training may be stated in terms of license or experience levels (i.e., apprentice pilot, licensed pilot with greater than 10 years experience, at least 5 years experience with vessels greater than 80,000 dwt), although it would be preferable to identify them in terms

similar to those utilized in describing the desired skill levels.

Ideally, all students who have approximately the same level of expertise should be grouped together within a particular class. This would hopefully allow each pilot to proceed through the program at the same rate. Use of license level, vessel type experience, etc., may be discriminatory in this regard when accepting applications. From a logistical perspective once the pilots arrive at the training facility, it is usually difficult to shift them to another class grouping that may be more appropriately based on their skill levels. It then becomes a matter of adapting the training program as appropriate to the strengths and weaknesses of the class as a whole.

Techniques of varying levels of sophistication can be utilized by a simulator-based training facility to identify skill before training once the pilot arrives at the training facility.

Level I: No Diagnostic Evaluation. The skills already possessed by the pilots prior to their participation in the training program are not evaluated. A standard training program is provided, addressing a fixed set of training objectives, independent of trainee entry skill proficiency.

Level II: Evaluation via Discussion. Each pilot completes a questionnaire or participates in an interview/discussion with the instructor which allows an assessment of the trainee's individual skills. The instructor, upon completion of all trainee interviews, makes an evaluation of group proficiencies and deficiencies. The training program is then tailored as appropriate to meet the needs of each group.

Level III: Simulator Diagnostic Evaluation. A pretest simulation scenario is administered individually to each pilot prior to his participation in the training program. Each individual's performance is evaluated against a set of minimal acceptable standards. The strengths and weaknesses of the group as a whole are determined based on the results of the diagnostic evaluation and the training program is tailored as appropriate to meet the needs of the group.

3.3.3 Training Objectives

Training objectives are the progressive goals of the individual training modules which build on the trainee's skill levels prior to training and culminate with the trainee's attainment of the desired skill levels. The magnitude of the improvement goal for each progressive training objective will depend on many factors including the skill and knowledge of the trainee, the difficulty of the skill being taught, the trainee's motivation, the ability of the instructor, etc. Training objectives should be written in terms of (1) the desired skills or knowledge to be attained, (2) the conditions under which the student should be able to perform the new skill, and (3) the performance measures and standards to be employed to measure the attainment of this goal. The detail of a program's training objectives may vary as indicated below.

Level I: Very Flexible. The training objectives are written in general terms relating to the program goals or training module goals. They are not tied specifically to any particular topic areas or simulator exercises. Example: "The trainee shall demonstrate proficiency in handling preselected vessels after a loss or degradation of propulsion power with

confined channels under various conditions of wind, current, water depth, and visibility."

Level II: Moderately Structured. The training objectives are written for each topic area to be covered within the training program or training module. These training objectives have more detail than the Level I training objectives discussed above. Example: "The trainee shall demonstrate proficiency in handling an 80,000 dwt tanker after a loss or degradation of propulsion power within a 1500 foot channel under various conditions of wind, current, water depth, and visibility."

Level III: Highly Structured. The training objectives are written for each simulator exercise within the training program. Example: "The trainee shall maintain a full-loaded 80,000 dwt tanker on the centerline of a 1500 foot channel for at least 20 minutes after a loss of propulsion power under the following conditions: wind - none, current - 1 knot cross channel, bottom clearance - 5 feet, visibility - unlimited."

3.3.4 Training Techniques

Training techniques are structured or unstructured methods of instruction used to teach the trainee how to perform various tasks so as to satisfactorily achieve the program's training objectives.

When conducting simulator-based training programs, no single training technique will normally suffice. Various techniques should be used to provide adaptation for individual differences. This will ideally allow the attainment of a high level of performance from all trainees. As exercises are developed, selection of training techniques should be based upon:

- Skills prior to training
- Desired skills after training
- The training objectives
- The time available for training
- Training aid (i.e., simulator) capability and availability
- Overall training cost

There are a number of training techniques that may be utilized during shiphandling/navigation simulator-based training programs. Four of the most relevant techniques that have been successfully employed for such simulator-based training are described below.

Knowledge of Requirements

Knowledge of requirements involves the presentation to the student of specific aspects of the pending training exercise prior to its conduct on the simulator (i.e., definition of problem). The purpose of this training technique is to eliminate the element of surprise from the training process until the student acquires the basic skills to perform the task when there is sufficient time to anticipate proper action. For example, if emergency shiphandling skills involving the reaction to a loss of power in a restricted channel are being taught, it would probably be desirable to train the students to handle the casualty without the element of surprise initially. After they have been adequately trained in the proper procedures and control actions to respond to the casualty, it would be then appropriate to add the element of surprise by initiating the casualty unannounced during later scenarios in the training program.

The methods for disseminating knowledge of requirements can vary as follows:

Level I: Specific Knowledge of Requirements. The instructor, prior to the trainee's participation in the exercise, explains the specific type of problem to be encountered, factors affecting the solution, and all criteria upon which performance will be evaluated. This level of knowledge of results is recommended for training when new concepts are being introduced or new skills are being developed.

Level II: General Knowledge of Requirements. The instructor, prior to the trainee's participation in the exercise, explains the general goals of the exercise and the criteria upon which his performance will be evaluated. He does not, however, explain the specific details of the pending exercise.

Level III: No Prior Knowledge of Requirements. In specific cases it may be appropriate not to provide experienced pilots with the knowledge of the exercise requirements when attempting to develop specific decision-making and judgmental skills. The pilot normally does not find scenarios at-sea that involve particular skills which were discussed just prior to their encounter. As a result, he should be able to recognize that a problem exists, properly define it, then take appropriate action.

Positive Guidance

Positive guidance is a technique whereby relevant information concerning the appropriate procedures or behavior is provided to the students prior to or during the training exercise on the simulator. That is, the instructor positively guides the students by explaining, demonstrating, or providing evaluative commentary during the exercise as regards the proper considerations and actions to be taken. This technique will assist the trainee in making the link between critical information (i.e., range/closing rate) with appropriate pilot action (i.e., range at which maneuver is initiated).

Positive guidance should be employed early in the training process to ensure that the essential behaviors are learned. Positive guidance should then be removed and feedback on student performance is then provided solely by the postproblem critique. Caution should be exercised that positive guidaance by the instructor does not become a necessary crutch for successful pilot performance, since in the at-sea environment the instructor will not be available to provide such assistance. Various levels of positive guidance can exist.

Level I: No Positive Guidance. No positive guidance/relevant information is given to the trainees prior to or during the training exercise on the simulator regarding the appropriate procedures to be followed or the behaviors to be exhibited (i.e., post problem critique only). There is a danger that inappropriate behavior may be reinforced by this technique and may become difficult to overcome during the remainder of the training program. Desirable behavior should be emphasized, demonstrated, and practiced at every opportunity. Therefore, some amount of positive guidance should be employed particularly during the early stages of training.

Level II: Verbal Explanation. The instructor verbally explains to the trainees the appropriate procedures to be followed and behaviors to be exhibited prior to and possibly during the training exercise on the simulator. If positive guidance is provided during the exercise, care should be exercised that it does not become an operational crutch as indicated above.

Level III: Demonstration. The instructor verbally explains the appropriate procedures to be followed and the behaviors to be exhibited and then demonstrates on the simulator how the exercise should be performed, prior to the trainees participating in the simulator exercise.

Level IV: Detailed Analytic Introduction. The instructor verbally and through use of audio visuals or other training assistance technology, explains the appropriate procedures to be followed and behaviors to be exhibited. (See discussion of Training Assistance Technology, Level II: Feedback Display, page 34).

Adaptive Training

Adaptive training is a technique that varies the difficulty of tasks as a result of how well the trainee operates or performs on specific previously conducted tasks. As the trainee gains in skill, the trainee's tasks are made more difficult. This type of training represents a progressive training approach; it starts with basic tasks, goes to intermediate tasks, and finally to advanced level tasks. A key point is that the trainee progresses at his own rate through the program, based on his exhibited skill at each step. For example, adaptive training in shiphandling may have an apprentice pilot navigating an 30,000 dwt tanker around a 30 degree turn in a narrow channel with no wind, no current, and no traffic as a basic level task. An intermediate level task may be the navigation of the 30,000 dwt tanker around the 30 degree turn with 25 knots of wind and 1.5 knots of flood current. The most advanced level of training may require the trainee to navigate the same vessel through the same turn under 25 knots of wind and 1.5 knots of flood current, while avoiding two traffic vessels.

Adaptive training should be considered in the development of the scenario sequence as presented within the training program. Two major constraints in the implementation of this technique are (1) the availability of adequate performance measures to assess individual student proficiency and (2) a workable training program structure to accommodate varying rates of advancement for individual students. The latter constraint may not be a particular problem with small classes (i.e., less than three students), since adequate flexibility may be available.

Level I: No Adaptive Training. A standard training program is provided addressing a specific sequence of tasks of a predetermined difficulty level. No attempt is made to follow a progressive training approach based on the rate of advancement of the particular students.

Level II: Group Adaptive Training. The difficulty level of training is tailored to meet the needs of a group of trainees, not each individual trainee. The level of difficulty will progress from basic through intermediate to advanced, based on the group's performance.

Level III: Individual Adaptive Training. The difficulty level of tasks is varied as a result of how well the trainee performed on previously conducted tasks. The trainee progresses at his own rate through the program, first performing basic tasks then intermediate and finally advanced level tasks.

Post Problem Critique

Post problem critique is a method of providing feedback regarding actions performed by the trainee in each simulator exercise. This technique should be employed immediately after each simulator exercise in order to maximize the benefit of the simulator training. It is recommended that the training program not be structured such that a post problem critique is employed only after several scenarios have been conducted on the simulator. This recommendation is made so as to minimize any confusion that may result in the trainee's mind between his behavior or control action on one scenario with the resulting vessel performance on another scenario. During the post problem critique, the instructor should:

- Emphasize and reinforce correct procedures and desirable behavior
- Point out specific errors in procedures/behavior and explain their relationship to vessel performance (i.e., resulting CPA)
- Provide specific instructions on alterations to procedures/behavior in order to improve performance on future exercises
- Provide a discussion and, if appropriate, a demonstration of the benefits of correct procedures/behavior. This discussion/demonstration may be facilitated by the training assistance technology features previously discussed.

During the post problem critique the instructor should encourage student participation in the analysis of the previous exercise. This is particularly true when training pilots who usually have a wealth of experience upon which to draw.

The timing and completeness of post problem critique may vary as follows:

Level I: Multiple Exercises. The instructor reviews the material only after several simulator exercises have been completed. There may be a danger that this type of feedback may result in confusion in the trainees mind between his behavior on one scenario with the resulting vessel performance on another scenario.

Level II: Single Exercise, Verbal Feedback. A solely verbal critique of each simulator is given by the instructor immediately upon its completion. This level of feedback may be given in the classroom or on the simulator between scenarios.

Level III: Single Exercise, Multi-Media. The instructor uses verbal critique, classroom discussions and some form of training assistance technology to critique each simulator exercise immediately upon its completion.

3.3.5 Instructor's Guide

An instructor's guide should be developed and provided to all instructors who are to conduct the training program. The guide should set forth (1) the structure -- the overall plan of training, (2) the strategy -- detailed methodology and timetable for each hour of training, and (3) the materials used to enhance the training process. Such a guide is needed for two purposes (1) to provide detailed guidance to the instructor to ensure that relevant issues are covered in an appropriate manner, and (2) to somewhat standardize the content of the training program should multiple instructors be used.

Below is an outline of what should be contained in an instructor's guide.

I. Program Introduction

   A. Purpose of the training program

   B. Description of the training program

   C. Schedule

   D. Bridge Team Assignments-(if applicable) on and off watch bridge team locations (e.g., on-watch team is on the bridge; off-watch team remotely observing)

II. Simulator Familiarization

   A. Description of simulator capabilities and limitations

   B. Demonstration of bridge equipment

   C. Demonstration of ownship handling characteristics

   D. Standing orders

III. Training Category (e.g., shiphandling)

   A. Specific training objectives to be achieved at the completion of the program. Objectives should describe:

      1. Overt behavior
      2. The conditions under which the behavior is to be performed
      3. Performance measures and standards (e.g., the trainee should demonstrate proficiency in handling a specific type and size of vessel to avoid collision and pass at a safe distance with other traffic under various conditions of wind, current, and water depth)

   B. Detailed lesson guides for each hour of classroom instruction, each simulator session, and each feedback session.

      1. Each hour of classroom instruction should have detailed:
         a. The specific topic to be covered (e.g., safe vessel speed for a particular size and type of vessel under a variety of operational conditions)
         b. The training methodology to be used -- detailing sample questions to be asked and points to be stressed
         c. All training materials/media to be used during this classroom segment
         d. The number code of the scenarios associated with the particular topic addressed
      2. Each scenario should have detailed:
         a. The specific training objectives to be achieved, including the appropriate performance measures and standards
         b. The methodology to be followed (i.e., demonstration of trainee hands-on)
         c. The coded scenarios to be run (specific scenario descriptions must be supplied in an appendix)
      3. Feedback sessions should have detailed:
         a. Training displays to be used, a description of acceptable performance to which the trainees' performance can be compared and evaluated

C. Course Evaluation/Student Debriefing
   1. Upon completion of the entire training program the trainees should be given the opportunity to verbally evaluate the program. They should also be required to complete a debriefing questionnaire regarding the various aspects of training. It is recommended that the debriefing questionnaire request the following information:
      a. Simulator comments (e.g., realism of visual scene, radar)
      b. Training program comments (e.g., program organization, length, instructor effectiveness)
      c. General comments (e.g., improvements in course)

D. Appendices
   1. The following more detailed information should be contained in the appendices to the instructor's guide as appropriate:
      a. Student handouts including a description of the training program, training program schedule, standing orders, ownship handling characteristics, description of the bridge configuration, and the debriefing questionnaire to be administered upon completion of the training program
      b. Any written tests and homework assignments
      c. Appropriate description of test and training scenarios
      d. List of reference texts used or case studies employed

The following levels represent types of instructor guides that may be used in various training programs.

Level I: No Documented Instructor's Guide. Each instructor teaches the course using his own structure, strategy, and materials. Little detailed coordination or consistency in what is taught exists between instructors.

Level II: Undocumented Instructor's Guide. No documented guide exists, however all elements of training are periodically discussed and agreed upon by all instructors teaching the course. This is apparent from observed similarity among instructors' materials, manners, and methods.

Level III: Documented Instructor's Guide. A written document is supplied to all instructors teaching the course. It details the overall plan of training, the topics to be covered, the training techniques to be employed and the support materials to be used.

3.3.6 Classroom Support Material

The types of material/media available for the instructor to utilize during the classroom sessions is another key element of an effective simulator-based training program. Several types of material/media that have been successfully employed in the past and should be considered for use at various points throughout the training program include:

- Traditional classroom chalkboard
- Appropriate scale charts of the geographic gaming area
- Overhead projector transparencies
- Sound-slide presentations (i.e., an audio cassette tape synchronized with a series of 35mm slides)

- Computer-generated graphic feedback displays*

- Remote monitoring of pilothouse personnel and key navigation parameters*

- Videotape monitoring of pilothouse personnel and key navigation parameters*

The selection of proper classroom support material/media should take into consideration a number of factors including (1) the subject matter content of each training objective, (2) the skill levels of the students prior to training, and (3) the strengths and weaknesses of the instructional staff. As with the selection of training techniques, no single type of classroom material/media will suffice when conducting a simulator-based training program. A repertoire of different materials should be available for the instructor to assist in adapting for individual instructor and trainee differences.

Classroom support material can range from traditional materials to advanced technological materials.

Level I: Basic Support Material. The instructor relys heavily on the use of the chalkboard and predeveloped handout materials to illustrate the concepts of the subject matter being taught.

Level II: Support Media. The instructor uses media such as the overhead projector and sound slide presentations in addition to the chalkboard and predeveloped handout materials to illustrate the concepts being taught.

Level III: Advanced Support Media. The instructor uses state of the art media such as computer-generated graphics, remote monitoring, and videotaping as classroom support material in addition to the traditional support media/materials.

3.3.7 Simulator/Classroom Mix

The proper combination of simulator and classroom time is important for effective simulator-based training. There appears to be a tendency among many pilots to want to spend the entire training program conducting exercises on the simulator. Such an approach may result in the trainees gaining "experience" by primarily a trial and error basis. This, however, usually is not the most effective or most economical means of developing the desired shiphandling/navigation skills. Adequate classroom time (i.e., prebriefing and postbriefing) should be included in the training program in order to:

- Provide the trainees with the necessary background knowledge required to adequately complete the simulator exercise (prebriefing).

- Provide appropriate guidance to the trainees regarding the correct action to be performed in a specific situation. For example, the instructor might discuss the effect of alternative rudder magnitudes and initiation points for navigating ownship through a 30 degree turn in a buoyed channel, and also make an appropriate recommendation prior to the simulator exercise (prebriefing).

- Provide the opportunity for seminar-type discussion in order to increase student involvement and draw on the experience of the trainees themselves.

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*Note: See discussion of "Training Assistance Technology" under Simulator Characteristics.

- Evaluate and critique trainee performance on the simulator exercises in a thorough and professional manner.

Sometimes logistical and economical considerations significantly reduce the amount of simulator time available for training (See Paragraph 3.3.8). Each trainee, however, should have an adequate simulator familiarization period in order to eliminate any confusion with bridge hardware that may hinder the learning process. This familiarization period should also be sufficient to develop an appreciation/ acceptance for the simulator's capability as a device for training the identified skills. Each trainee should have the opportunity to have hands-on experience at least once (preferably more) for each major topic area addressed. For example, when instructing students in the use of a rate-of-turn indicator for making constant radius turns, each student should handle the vessel in at least one turn, although the geometry of the turn, the size of the ship and the wind, current or visibility may vary between students. In fact, these parameters should vary in order to ensure the development of generalizable skills with a high probability of transfer to at-sea situations.

Experience has indicated that the proper simulator/classroom mix may vary depending on (a) the type of skills involved, (b) the proficiency/experience levels of the trainees, and (c) the stages within the training process. Several mixtures of classroom/ simulator time may be described as follows:

Level I: Predominant Simulator Time.

- A preexercise briefing in a classroom is not provided for each exercise although an initial classroom session is provided for the particular training module.
- Limited postexercise feedback is given the student, possibly on the simulator while resetting scenarios.
- The instructor may provide appropriate guidance and critique during the actual exercise.
- May be appropriate for acquiring/ refreshing basic-level skills, such as the use of the rate-of-turn indicator, that require repetition/ practice by the individual pilot.

Level II: Simulator/Postbriefing Mix.

- A preexercise briefing in a classroom is not provided for each exercise although an initial classroom session is provided for the particular training module.
- The postbriefing session is comprehensive and is conducted not on the simulator but in an appropriate classroom.
- May be appropriate for the later stages of training involving complex skills, such as Rules of the Road or Decisionmaking. These skills generally require the integration of a number of more basic skills. Early in training a preexercise briefing is important to provide the proper perspective for learning. However, such guidance should be eliminated as training process. See Paragraph 3.3.4, Positive Guidance.
- May be appropriate for the training of the above mentioned complex skills when the trainees are already proficient in the basic skills employed.

Level III: Prebriefing/Simulator/ Postbriefing Mix.

- A preexercise briefing in a classroom is provided for each exercise.
- The postbriefing session is comprehensive and is conducted not on the simulator but in an appropriate classroom.
- May be appropriate for the initial training of complex skills as defined under Level II: Simulator/ Postbriefing Mix.
- This level appears most appropriate for apprentice level training. Experienced pilots generally do not require and do not desire the amount of preexercise guidance that is usually appropriate for apprentices.

3.3.8 Training Program Duration

When determining the appropriate length of a simulator-based training program, a number of issues should be considered. First of all, program duration may differ based on the nature of the skills to be trained, with the more complex skills and situations requiring task integration. These need longer programs to ensure mastery of both the basic and integration skills. Second, the program duration may vary based on the input characteristics of the trainees. If the proficiency of the entering student's prerequisite skills is lower than anticipated, additional training may be required, and hence a longer training program. Conversely, if the proficiency of the entering student is higher than anticipated, then a shorter training program may be sufficient. Third, economics may impose a restraint on the training program duration. Due to the relatively high cost of simulator time and limited resources available for training, it usually becomes imperative that only intensive, cost effective training programs be offered. Finally, the length of the program may also be constrained by the amount of time that prospective trainees have available for such training. Based on all the above considerations, training program durations from 1 day (8 hours) to 1 week (40 hours) may be appropriate. Additional information on three different program durations is provided below:

Level I: One Day (8-hours).

- Appropriate for training involving limited subject material or acquisition of one basic skill such as use of the rate-of-turn indicator in constant radius turns.
- Appropriate for refreshing a limited number of skills such as the use of several advanced instruments or the handling of a specific vessel type that the pilot has not seen in several years.
- Caution should be exercised when utilizing such a short course due to the following reasons: (1) if bad habits have already been engrained in the entering students, sufficient training time may not be available to overcome such undesirable characteristics, (2) sufficient training time may not be available to ensure generalizable skills which are readily transferable to at-sea situations, and (3) sufficient training time may not be available to ensure high retention of skills particularly under stressful situations.

Level II: Three Days (24-hours).

- Appropriate for training involving broader subject material or acqui-

sition of several basic skills. Training the use of multiple piloting instruments, such as rate-of-turn indicator, racons, and precision navigation display, would fall into this level. Likewise, three days should also be considered for training shiphandling relating to unusual, high risk vessels such as VLCC's or LNG vessels, particularly if the pilot has not handled similar ships previously.

- Appropriate for refreshing a greater number of skills than the Level I: One Day (8-hour) program. Emergency shiphandling for experienced pilots would probably fall into this level of Training Program Duration.

Level III: Five Days (40-hours).

- Appropriate for training complex skills which involve the integration of other more basic skills. Apprentice pilot training in Restricted Waters Navigation, Shiphandling, or Emergency Shiphandling should be considered for training program of this duration. This would, of course, depend on the existing skills and proficiency levels already possessed by the trainees.

3.3.9 Class Size

The number of students in a simulator-based training program class is another important training program characteristic. Several factors should be taken into consideration. The principal factor is that all trainees should have adequate simulator hands-on training to acquire the desired skills, transfer them, and retain them within the operational environment (See Paragraphs 3.3.12 and 3.3.13). Since only a finite amount of simulator time is available within the training program, the maximum class size is, therefore, usually established. Training facilities would naturally want to maximize the number of students within a class for economic reasons. The input characteristics of the trainees, the qualifications of the instructor, the availability of training assistance technology also can impact class size. Additional information on three different levels of class size is outlined below.

Level I: Greater than Six Students. Classes of this size may be effective in allowing the instructor or several students to demonstrate proper shiphandling/navigation techniques. Additional benefits may be gained through the use of the proper training assistance technology to observe and analyze performance (See Paragraph 3.2.7). However, generally speaking, class size of greater than 6 students is not recommended at the pilot level due to the substantial reduction in the amount of individual simulator "hands-on" training available. Students at this level generally have adequate knowledge. It is with regard to the skill in applying that knowledge where the training benefit lies. It may, however, be appropriate for some apprentice training objectives. Class sizes on the simulator should not exceed 10 under any circumstances; likewise, classroom class sizes should not exceed 25 students.

Level II: Six or Less Students. This class size is recommended for the majority of training objectives at the marine pilot level. It is small enough for an appropriate amount of individualized instruction and an adequate amount of simulator "hands-on" opportunities. A class size of four pilots was employed during the successful prototype program at CAORF.

It should also be noted that for many training objectives it may be desirable to divide the class for the simulator exercises into bridge teams consisting of two or three members each. This allows greater participation by the students and also provides the opportunity to observe shiphandling problems from the helmsman or master's perspective.

Level III: Three or Less Students. Classes of this size are recommended for the development of skills that require considerable individualized instruction and a relatively high number of individual "hands-on" opportunities. An example of a training area, in which classes of three or less students may be appropriate, would be Apprentice Pilot Shiphandling for the development of advanced skills in compensating for bank effect, passing ship effect, use of tugs, etc. The individual pilot association should, of course, investigate and accept the fidelity of the simulator for training these skills.

3.3.10 Scenario Design

The scenarios to be utilized as training exercises within a simulator-based training program should be based on the identified training objectives. Considerable thought should be given to the design of these scenarios in order that each accomplishes its intended objective(s). Care should be exercised that too many training objectives are not attempted in any one scenario. If more than one training objective is covered during a scenario, they should be clearly prioritized as primary and secondary objectives.

Scenarios should be sufficient in length to allow the hands-on trainee to develop a mental awareness of the problem in the simulated environment; evaluate the situation, take his action and observe the result of his actions. Attempts to shorten scenarios by eliminating any of these elements may greatly reduce the effectiveness of the time on the simulator. Minimum time for a shiphandling/navigation scenario appears to be about 20-30 minutes.

Scenario complexity is another important consideration when designing a scenario for a simulator-based training program. It is recommended that the scenarios be designed within the training program such that the complexity level is progressively increased as the latter scenarios are presented. That is, the initial scenarios should be of low complexity, the middle scenarios should be of medium complexity, and the final scenarios should be of high complexity. This type of structure allows the trainees to initially focus on the tasks to be achieved without complicating the situation with a variety of extraneous conditions, thereby allowing the trainees to first become proficient in performing various skills. (See corresponding discussion, paragraph 3.3.12 Stress).

It is important that scenarios for experienced pilots be (a) relevant to their pilotage area and (b) provide an appropriate level of difficulty. Experienced pilots are not interested in performing tasks that they perform every day. They are interested in performing tasks on the simulator that they would not normally perform at-sea. Emergency or unusual operational conditions appear particularly appropriate.

Scenarios which are to be employed as exercises during a simulator-based training program should be thoroughly checked-out and the necessary modifications made prior to the commencement of the training. This check-out

should involve several subjects with shiphandling expertise equivalent to that of the trainees expected for the program. Refinement of the scenarios after experience is gained with the training program should be encouraged in order to maximize the efficiency and effectiveness of the training.

Three levels of scenario design are discussed below.

Level I: Basic Skill Scenario. This type of scenario usually involves a single task or a single skill such as maneuvering a 30,000 dwt tanker around a 30 degree turn in a buoyed channel. These scenarios are usually relatively short in duration and allow the student to focus attention on the specific skill to be developed. They are normally employed during the initial stages of training, particularly with apprentice pilots.

Level II: Intermediate Skill Scenario. This type of scenario usually involves multiple tasks or multiple skills, which the student may be required to perform simultaneously. For example, the student may handle a 30,000 dwt tanker around a 30 degree turn in a buoyed channel while encountering various traffic vessels. This type of scenario focuses the student's attention on the integration of skills that he has previously acquired.

Level III: Advanced Skill Scenario. This type of scenario is similar to that discussed above for Level II, except that it involves the addition of operational noise or distractions which complicate the scenario. For example, the student may handle the 30,000 dwt tanker in the 30 degree turn previously mentioned while encountering traffic vessels under restricted visibility conditions or degradation of propulsion power.

3.3.11 Number of Scenarios

The question of how many scenarios to employ within a simulator-based training program in order to allow sufficient practice on various sequences of tasks will depend upon the training objectives to be achieved. In general, for each training objective listed within the training program there should be at least two somewhat similar corresponding simulator exercises which would incorporate all the tasks required to achieve that objective. For example, if a training program had the following shiphandling training objective: "the trainee should demonstrate high proficiency in determining safe vessel speed (± 1 knot) when handling a 110,000 dwt tanker in a high traffic density, port approach scenario with visibility between 1.0 to 2.0 nautical miles" at least two scenarios should be incorporated for training this skill. Additional scenarios may be appropriate for training the same skill under different conditions (i.e., visibility 10-12 nautical miles, different levels of traffic density). In fact, sufficient scenarios with a wide variety of conditions should be employed in order to ensure that generalizable skills are being taught, which have a high probability of transfer to at-sea situations. If too few scenarios with too few conditions are utilized, a danger exists that the trainee will acquire only the specialized skill to handle a few specific scenarios, which he may never encounter at sea. In fact, with regard to restricted waters shiphandling training, if generalizable skills are desired, not only should multiple scenarios be employed but also multiple geographic and environmental data bases (i.e., different ports). After sufficient scenarios are available for developing the basic skills, additional scenarios should

then be incorporated into the training program for skill integration, stress, and overlearning considerations. (See discussions under corresponding Training Program Characteristics).

Level I: Minimal Practice. Sufficient scenarios should be available for a particular training program objective such that at least one trainee completes the exercise successfully prior to advancing to the next training program objective.

Level II: Moderate Practice. Sufficient scenarios should be available for a particular training program objective such that at least two trainees complete the exercise successfully prior to advancing to the next training program objective.

Level III: Desired Practice. Sufficient scenarios should be available for a particular training program objective such that all trainees complete the exercise successfully prior to advancing to the next training program objective.

3.3.12 Stress

This characteristic addresses the issue of stress induced by the scenario situations presented under each training category. It should be noted that high stress is generally considered disruptive to training since it slows the learning process. Often, the instructor and his training strategy is the greatest source of stress. A positive approach by the instructor showing correct behavior is usually most effective, as opposed to a negative approach that emphasizes trainee problems. The trial and error learning approach followed by some training facilities also has a high probability of inducing undesirable stress. This approach would place the pilot in a difficult situation and allow him to determine the correct approach over several trials. A preferred approach would be to show the correct action, or acceptable actions, prior to putting the trainee in the simulator. Stress should be minimized for those aspects of shiphandling training that deal with normal conditions. Attempts should also be made to minimize stress for abnormal and emergency conditions in order to facilitate the training of skills and specific response patterns (e.g., crash stop). After the requisite shiphandling skills have been achieved to the criterion level of performance, stress should be introduced in training for the specific purpose of training the pilot to satisfactorily perform under stressful conditions. Such methods of increasing stress would include increasing the traffic complexity, reducing the time available to react to the given situation, adding more noise on the radar, increasing the scenario complexity, having the pilot perform more tasks, etc. New skills would not be trained at this time; rather, only the conditions would be changed from low to high stress. Since pilots are likely to perform differently under stress, such training is desirable.

Level I: Low Stress.

- Anticipated Shiphandling Tasks
- Maximum Time Allotment
- Low Scenario Complexity
- Minimum Noise/Distractions

Level II: High Stress.

- Unanticipated Shiphandling Tasks
- Minimum Time Allotment
- High Scenario Complexity
- Substantial Noise/Distractions

Level III: Progressive Stress.

- Initial Training Scenarios - Low Stress
- Final Training Scenarios - High Stress
- Stress Level Increased as Students Adapt

3.3.13 Overlearning

Learning is the process by which the trainee acquires new skills at the level of proficiency set forth in the training objectives. Learning is said to be complete when mastery is achieved for a particular training objective. Overlearning occurs when the learning/training process is continued beyond the achievement of the performance standard by providing additional exposure to a variety of scenario situations that require the use of the newly acquired skills.

Overlearning is a desirable characteristic of the training process in that it improves the confidence of the trainee and thus results in a greater depth of skill, an assurance of skill generalizability to other situations, a greater retention of skill after training, and a higher probability of using the learned skills when necessary. Overlearning has been found to be a necessary condition to assure adequate performance during periods of emergency and stress and to assure that the trained and measured performance transfers to other situations and other aspects of the situation that were not measured. Hence, due to the complexity of the shiphandling problem, overlearning should often be accomplished by pilots particularly when the training objectives deal with performance during emergency periods and under other stressful conditions.

Caution should be exercised that overlearning does not give the trainee a false sense of confidence, which results in his taking greater risks than necessary at-sea based on an inflated perception of his ability to handle the situation. This may be particularly dangerous if the scenario designs are too easy and do not tax the trainee's ability to perform or provide him with a proper sense of the gravity of the situation.

Two levels of this characteristic are described below:

Level I: No Overlearning. Training results in the achievement of the minimum acceptable performance standards specified for each training program objective.

Level II: Desired Overlearning. Training results in the achievement of the minimum acceptable performance standards specified for each training program objective if evaluated six months later under conditions of high stress.

3.4 INSTRUCTOR QUALIFICATIONS (CRITICAL CHARACTERISTICS)

It is generally well-recognized in the training literature that the instructor can have a substantial impact on the effectiveness of a particular training program. Previous CAORF research has indicated that the instructor is extremely critical for effective shiphandling/ship bridge simulator training at the master/chief mate level. It is believed that the instructor is also extremely critical for effective training at the marine pilot level although this has never been investigated directly. The qualifications of an effective instructor for simulator training are complex. The following are the critical characteristics of an instructor for training marine pilots via a shiphandling/ship bridge simulator which

are discussed in this section of the report:

- Mariner credentials
- Instructor credentials
- Subject knowledge
- Instructor skills
- Instructor attitude
- Student rapport
- Instructor evaluation

3.4.1 Mariner Credentials

The license level and at-sea experience of the instructor is important to ensure the creditability of the training program with the students. While it is not necessary that a pilot-level instructor have a pilot's license, lack of such credentials could provide a handicap that the instructor would then have to overcome during the training program. From the other perspective, the fact that an instructor has a pilot's license does not ensure that he is an effective instructor. Many other characteristics must be considered as outlined later in this section.

Level I: Master License (Minimum 10-Years At-Sea). Instructors with senior deck officer credentials are presently being successfully employed in Germany for the simulator training of marine pilots. Although different attitudes may exist between German pilots and American pilots, it is believed that, while not recommended, it is possible for an instructor to be effective in training selected skills to American pilots without being a pilot himself.

Level II: Pilot License (Minimum 3-Years At-Sea). An instructor with this level of mariner credentials may be appropriate for apprentice training. In fact, recency of the instructor's own apprentice training may be advantageous for improving his rapport with the students.

Level III: Pilot License (Minimum 10-Years At-Sea). An instructor with these credentials would be desired for the majority of marine pilot simulator training. Such credentials probably would be required for training experienced pilots. Although a pilot's license or endorsement appears to be the best credentials, consideration should be given to the potential instructor's specific experience and the currency of this experience, since the type and amount of restricted waters shiphandling expertise may vary widely among individual pilots.

3.4.2 Instructor Credentials

A fundamental background/experience in teaching or instructional techniques is an important characteristic for a simulator-based training instructor. The ability to organize a lesson, communicate concepts, and relate to people is as critical when training pilots as with other groups of comparable students. The potential instructor may have obtained his instructor credentials through any of the following routes:

Level I: Previous Instructor Experience. A potential simulator-based training instructor may have acquired his instructor credentials through experience in other non-simulator training programs involving students of equivalent backgrounds. This individual may or may not have appropriate educational certificates. However, it is very important that he recognize his role as an instructor and not simply the coordinator of simulator exercises.

Level II: Instructor Course. It would probably be appropriate for

training facilities to provide their potential instructors with special training in the use of the simulator as an educational tool even if the individual has had previous teaching experience. The unique nature of the simulator as a training device, the high cost of simulator-based training, and the importance of the instructor in providing effective training, appear to make it prudent that the instructors be well-versed in the use of their expensive training device. It would not be necessary that such a course be tailored to the facility's specific simulator, although this would be desirable.

Level III: Educational Certificate. A graduate of a recognized institution which prepares individuals for careers as teachers within a given state school system. The individual's training should be concentrated preferably in the area of adult education. It is anticipated that commercial training facilities may have difficulties in attracting individuals with both satisfactory mariner credentials and this type of instructor credentials. However, it would appear desirable for the facility to encourage their new instructors to work toward such an educational certificate.

3.4.3 Subject Knowledge

The knowledge and familiarity of the instructor with the subject material to be presented is another important characteristic. The instructor should have a high level of understanding in the particular subject area in order to effectively communicate the concepts involved and, in some cases, their subtle applications. It is also desirable that he be a "student" of specific subject areas, such as Rules of the Road, aids-to-navigation, shiphandling, etc., in addition to a successful practitioner. Since it may be rare to find individuals who possess such depth of knowledge in the desired subject areas, it is perhaps more important to ensure that the potential instructor has the proper attitude towards seeking out a greater level of knowledge on the subjects to be taught in order to improve his base for instruction (see paragraph 3.4.5).

Level I: Satisfactory Knowledge.

- Understands all appropriate shiphandling and navigation principles.
- Understands the application of these principles for a variety of vessel types in a cross section of operational situations.

Level II: Exhaustive Knowledge.

- Understands all appropriate shiphandling and navigation principles.
- Understands the application of these principles for a variety of vessel types in a cross section of operational situations.
- Understands the historical development/evolution of present shipboard equipment, operational procedures, and regulations.
- Understands the impact of current regulations and technological changes on the inherent safety of the navigation process.

3.4.4 Instructor Skills

The instructor skills are those generic skills used by the instructor to conduct an effective training program, drawing on available training techniques, aids, and materials. A highly structured training program with appropriate supporting materials can substantially assist the instructor, and thus help to ensure an effective

training program. Automated, semi-automated, and manual training aids, such as the training assistance technology capabilities of the training device discussed earlier, can also substantially assist the instructor. Even with these types of assistance, however, the effectiveness of the training program will likely depend heavily on the instructional skills of the instructor -- such as his skill in organizing and presenting information. These instructor skills may result from formal education and/or experience; as such, they may be independent of the instructor's formal credentials.

The instructor should have the ability to organize and conduct a comprehensive preexercise briefing, which will effectively prepare the trainees by directing their attention towards the key concepts to be experienced/observed during the exercise. His ability to explain these concepts using language best understood by the students is also important. During the exercise, his ability to monitor and supervise the students in a constructive manner is critical. The proper amount of instructor interaction with the students, particularly the individual conning the vessel, can impact student motivation during the training program. Some students tend to become discouraged if the instructor is constantly offering "suggestions." In the postexercise feedback session, the ability of the instructor to focus on key problem areas in a constructive manner will assist in maximizing the benefits received by the student during the exercise. Well-designed computer-assisted feedback displays will assist the instructor in this area. However, he still must tailor discussion to the particular student's performance on the exercise.

The instructor should also possess the ability to identify students requiring special attention and provide same without diverting the entire class for long periods of time. In some cases, it may be more important that each trainee develop a basic understanding and necessary skills in a particular area, such as compensating for the effect of current on a particular vessel, than moving on to another area, such as passing ship effects, when only the advanced students have mastered the required skills.

The training methods used should always be tailored to the training situation -- training objectives, students, instructor skills, training aids available, and so on. Research conducted as a part of this project suggests that a seminar/case study methodology is effective for training experienced pilots. It provides for instructor guidance, detailed participation by the students in carrying out the training process, and considerable interaction between students and with the seminar coordinators. With this approach the experienced pilot students are part of the instructor team, with the coordinators acting to present information, guide discussions, and coordinate activities. Their breadth of experience should enable the rapid grasping of concepts and their appropriate application to a variety of situations. For inexperienced pilots (e.g., apprentices), on the other hand, lectures would likely be effective to augment the seminar sessions, as a means of presenting substantial amounts of information and a wide range of example applications. Other appropriate instructional methods should be used in accordance with the respective training situation.

Level I: Acceptable.

- Leads seminar discussions in an acceptable manner.
- Organizes classroom and simulator time in a manner which allows for improvement.
- Communicates concepts satisfactorily.
- Spends more time than is required in applying concepts to operational problems (e.g., too many sea stories).
- Uses basically one type of teaching method or training technique, usually focusing on aspects of poor performance.
- Evaluates student performance in a manner which some students may consider abrasive, although most students find acceptable.
- At least 80 percent of students perform satisfactorily after instruction.

Level II: Desirable.

- Leads seminar discussion well.
- Organizes classroom and simulator time effectively; conducts a structured training program.
- Communicates concepts well; speaks clearly and interestingly.
- Applies concepts to operational problems in a professional manner.
- Uses several training techniques satisfactorily to adapt for individual differences.
- Evaluates student performance in a positive manner which enhances motivation.
- At least 90 percent of students perform satisfactorily after instruction.
- Focuses training on the class average, with some individual attention.
- Provides good feedback to the students.

Level III: Outstanding.

- Leads seminar discussions in an outstanding manner.
- Organizes classroom and simulator time very effectively; conducts highly structured classes, with good difficulty progression across classes.
- Communicates concepts extremely well, using language best understood by the trainees; presents concepts in an interesting manner, relevant to their experiences.
- Applies concepts to operational problems in a professional manner.
- Uses a variety of training techniques effectively to adapt for individual differences.
- Effectively and accurately assesses student performance, including strengths and weaknesses.
- Focuses a substantial amount of training on individual needs, particularly sensitive to the poorer performers in the class.
- Provides highly detailed technical feedback, focusing on both good and poor aspects of performance.

- Evaluates student performance in a positive manner which enhances motivation.

- One hundred percent of students perform satisfactorily after instruction.

3.4.5 Instructor Attitude

The enthusiasm of the instructor for the training program material and his conviction as to the importance of the program are generally recognized as desirable instructor attributes. Instructor enthusiasm is not only contagious, but it also is the vehicle by which discrepancies or obstacles in the training process are successfully overcome. This enthusiasm should be sincere; the result of deeply held convictions by the instructor. The instructor's attitude should also be professional in nature, treating the development of sea-going skills from the proper perspective, due to the serious business of piloting today's large and costly vessels, with their sometimes hazardous cargos.

The instructor, however, should not have an overbearing view of himself and his job. Not only could this reduce student motivation, but it could also limit student-instructor interaction as discussed below in Student Rapport.

Level I: Reserved.

- Conveys subject matter with little emotion.

- Thoroughly answers but does not encourage questions.

- Neither motivates nor discourages students in attaining the proficiencies specified in the course objectives.

Level II: Positive.

- Conveys subject matter in a positive, professional manner.

- Stimulates moderate student participation in seminar discussions.

- Motivates students to attain the proficiencies specified in the course objectives.

- Exhibits moderate interest in the subject matter.

Level III: Enthusiastic.

- Conveys subject matter in a contagious, professional manner.

- Stimulates active student participation in seminar discussions; draws students into discussion.

- Creates a sincere desire for attaining proficiencies over and above the specific course objectives.

- Exhibits enthusiasm for the subject matter, and its application to shiphandling.

3.4.6 Student Rapport

The simulator-based training instructor should have the ability to develop personal relationships with the trainees which are conducive to the learning process. The students should feel free to ask questions without fear of ridicule. The instructor should be empathetic and constructive with his criticisms. He should provide appropriate support and encouragement during the training process. While it is not necessary that an instructor be well-liked by the students, it is important that they respect him as a professional.

Level I: Competent.

- Instructor possesses the technical skills and knowledge of the material being trained within the training program.
- Thoroughly answers but does not encourage questions.
- Instructor may not be viewed as shiphandler, although viewed as technically competent.

Level II: Respected.

- Instructor possesses the professional skills and knowledge of the material being trained within the training program.
- Instructor viewed as an example of the proficiencies to be attained as a result of the training program -- viewed as a competent shiphandler.
- Instructor approachable by students with questions concerning the concepts being taught.

Level III: Admired.

- Instructor possesses professional skills and knowledge substantially beyond those being taught within the training program.
- Instructor viewed as an example of the proficiencies to be attained as a result of many years of professional experience -- viewed as a very competent and senior pilot.
- Instructor easily approachable by students with questions concerning the concepts being taught; instructor makes very definite effort to draw students into discussion.

3.4.7 Instructor Evaluation

This characteristic refers to the evaluation of instructors conducted periodically by the training facility, to ensure consistently high quality of instruction. Each facility should develop and implement its own procedures regarding evaluation intervals and evaluation criteria. Two levels of instructor evaluation are discussed below.

Level I: Continuing. Instructor performance during each training program is monitored via student post-training proficiency tests and student evaluation forms in order to ensure the maintenance of high standards at the training facility.

Level II: Diagnostic. At periodic intervals (e.g., every six months) or when the continuing evaluation indicates a problem, instructor performance should be reviewed via a more comprehensive evaluation. This evaluation should provide the instructor with constructive criticism of his proficiency for each of the applicable training categories discussed in Section 2.

The evaluation session should be one in which the evaluators observe at least two classroom segments and at least two simulator exercises in a particular training category.

The following items should be evaluated regarding the instructor:

- Ability to organize a lesson
- Ability to conduct a lesson
- Ability to communicate concepts using language best understood by the students

- The instructor's level of understanding of the particular subject area
- Ability to utilize various training techniques effectively
- Ability to monitor and supervise the students in a constructive manner
- Ability to provide constructive feedback regarding a particular student's performance on an exercise
- Ability to identify students requiring special attention and providing it without diverting the entire class for long periods of time
- Enthusiasm for teaching the material
- Professionalism of the instructor's attitude
- Ability to develop good student rapport
- Improvement in student performance as a result of the training provided.

CHAPTER 4

RECOMMENDED TRAINING SYSTEM CHARACTERISTICS

Pilots and pilot associations interested in shiphandling/ship bridge simulator training should thoroughly investigate the potential benefits to be derived from a given training facility. In order to properly accomplish this evaluation, numerous judgements should be made relating to each of the critical training system characteristics identified and discussed in Chapter 3. The purpose of this section of the report is to provide the individual, who may be charged with such an evaluation, with relevant information and a decisionmaking structure for making these judgements.

The recommendations of specific characteristics for a marine pilot simulator-based training system is not an easy task. Not only should the optimum characteristics be related to the specific objectives of the training program, but the effectiveness of training is the result of the interaction of many complex factors. For example, as previously mentioned, a well-qualified instructor can compensate for certain deficiencies in simulator design (e.g., limited horizontal field-of-view). Likewise, a well-structured training program can assist a marginal instructor in organizing and implementing the course material.

Individuals and organizations interested in evaluating the potential of a given training facility to provide effective training for pilots should consider employing Tables 1-10 contained in this section of the report. One table exists for each of the ten Candidate Marine Pilot Training Modules previously identified. Each table contains both the recommended and minimum levels for each of the critical training system characteristics when training skills within a particular module. The recommended level is the description of the specific characteristic, which has been identified and discussed in Chapter 3, that the authors deem most appropriate for training the pilot skills within one of the training modules. The minimum level of the characteristic is the description of the most inexpensive configuration of the particular critical training system characteristic that the authors judge to be effective for training the majority of pilot skills within the particular module. Through a comparison of the recommended and minimum levels for each characteristics, a range of acceptability for the particular training system characteristics may be established.

It should also be noted that if a training facility meets all the minimum requirements for a particular training module, it still may not be acceptable for training that module. The minimum levels of these training system characteristics are established on an item by item basis. It is assumed that other elements of the training system could realistically compensate in a properly designed training system for this minimum level of the characteristic. For example,

in certain situations a black and white visual scene (i.e., minimum level) may be acceptable when color is recommended if the types of scenarios employed, the structure of the training program, and the procedures utilized by the instructor minimize the impact of this apparent simulator deficiency. The reader is reminded that the data contained in the following tables are the authors' interpretation of the guidelines set forth in Chapter 3 for each of the Candidate Marine Pilot Training Modules. For more information concerning the relationship between the effectiveness of training and the particular training system characteristics, please refer to Chapter 3.

Tables 1-10 may be employed as evaluation forms since space has been provided for the evaluator's comments that may be appropriate for each critical characteristic. It is also recommended that the individual conducting the evaluation summarize his findings for each of the three major elements of the training system, namely simulator design, training program structure, and instructor qualifications. A form similar to Table 11 may be employed for this purpose. Such documentation forces the evaluator to consider the contribution of each element of the training system prior to his establishment of the facility's potential to provide effective training in the desired skill area.

TABLE 1. EMERGENCY SHIPHANDLING - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	No Landmass	
Horizontal FOV	Greater Than 240°	120° to 240°	
Vertical FOV	Greater Than ±15°	±10° to ±15°	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
Radar Presentation	Low Fidelity	No Radar	
Bridge Configuration	Full Bridge	Full Bridge	
Ownship Characteristics	Special Effects	Special Effects	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneurverable	Canned Traffic	
Training Assistance Technology	Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Apprentice - Direct Improvement Others - Specific Opera- Training	- Direct Skill Improve- - Refresher Training - Specific Operational Training	
Skill Before Training	Evaluation Via Discussion	No Diagnostic Evaluation	

TABLE 1. EMERGENCY SHIPHANDLING - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Objectives	Highly Structured	Moderately Structured	
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
Instructor's Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	Apprentices - 5 Days (40 hrs) Others - 3 Days (24 hrs)	3 Days (24 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	

TABLE 1. EMERGENCY SHIPHANDLING - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-Sea)	Pilot License (Minimum 3 Years At-Sea)	
Instructor Credentials	Instructor Course	Educational Certificate	
Subject Knowledge	Exhaustive knowledge	Satisfactory knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 2. SHIPHANDLING - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Coastal	
Horizontal FOV	120° to 240°	120° to 240°	
Vertical FOV	$\pm10^{\circ}$ to $\pm15^{\circ}$	$\pm10^{\circ}$ to $\pm15^{\circ}$	
Time of Day	Day/Night	Night Only	
Color	Multi-Color	Black and White	
Radar Presentation	Low Fidelity	No Radar	
Bridge Configuration	Full Bridge	Reduced Bridge	
Ownship Characteristics	Special Effects	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneuverable	Canned	
Training Assistance Technology	Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 2. SHIPHANDLING - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
Instructor's Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation/Postbriefing Mix	Simulation/Postbrief-Mix	
Training Program Duration	5 Days (40 hrs)	3 Days (24 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-Sea)	Pilot License (Minimum 3 Years At-Sea)	

TABLE 2. SHIPHANDLING - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor Course	Educational Certificate	
Subject Knowledge	Exhaustive Knowledge	Satisfactory Knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 3. VESSEL CHARACTERISTICS - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Coastal	
Horizontal FOV	120° to 240°	120° to 240°	
Vertical FOV	$\pm 10^{\circ}$ to $\pm 15^{\circ}$	$\pm 10^{\circ}$ to $\pm 15^{\circ}$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
Radar Presentation	Low Fidelity	No Radar	
Bridge Configuration	Full Bridge	Reduced Bridge	
Ownship Characteristics	Special Effects	Special Effects	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneu-verable	Canned	
Training Assistance Technology	Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improve-ment	Direct Skill Improve-ment	
Skill Before Training	Evaluation Via Dis-sion	No Diagnostic Evalua-tion	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 3. VESSEL CHARACTERISTICS - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
Instructor's Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	3 Days (24 hrs)	1 Day (8 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea)	Pilot License (Minimum 3 Years At-sea)	

TABLE 3. VESSEL CHARACTERISTICS - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR			
Instructor Credentials	Instructor Course	Educational Certificate	
Subject Knowledge	Exhaustive Knowledge	Satisfactory Knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 4. PILOTHOUSE PROCEDURES - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Coastal	
Horizontal FOV	120^{0} to 240^{0}	120^{0} to 240^{0}	
Vertical FOV	$\pm 10^{0}$ to $\pm 15^{0}$	$\pm 5^{0}$ to $\pm 10^{0}$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
SIMULATOR DESIGN			
Radar Presentation	Low Fidelity	Low Fidelity	
Bridge Configuration	Full Bridge	Full Bridge	
Ownship Characteristics	Special Effects	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneuverable	Canned Traffic	
Training Assistance Technology	- Remote Monitoring - Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	

TABLE 4. PILOTHOUSE PROCEDURES - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Objectives	Highly Structured	Moderately Structured	
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
Instructor's Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	5 Days (40 hrs)	3 Days (24 hrs)	
Class Size	6 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea	Master License (Minimum 10 Years At-sea)	

TABLE 4. PILOTHOUSE PROCEDURES - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor Course	Educational Certificate	
Subject Knowledge	Exhaustive Knowledge	Satisfactory Knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 5. ADVANCED INSTRUMENTATION - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Coastal	
Horizontal FOV	120° to 240°	90° to 120°	
Vertical FOV	$\pm 10^\circ$ to $\pm 15^\circ$	$\pm 5^\circ$ to $\pm 10^\circ$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
SIMULATOR DESIGN			
Radar Presentation	High Fidelity	Low Fidelity	
Bridge Configuration	Full Bridge	Reduced Bridge	
Ownship Characteristics	Shallow Water	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Preprogrammed	None	
Training Assistance Technology	Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 5. ADVANCED INSTRUMENTATION - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
TRAINING PROGRAM			
Instructor's Gu[illegible]	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	3 Days (24 hrs)	1 Day (8 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea	Master License (Minimum 10 Years At-sea)	

TABLE 5. ADVANCED INSTRUMENTATION - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor's Course	Educational Certificate	
Subject Knowledge	Exhaustive knowledge	Satisfactory knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 6. RESTRICTED WATERS NAVIGATION - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Port Specific	Restricted Waters - Generic	
Horizontal FOV	120° to 240°	120° to 240°	
Vertical FOV	$\pm10^{\circ}$ to $\pm15^{\circ}$	$\pm10^{\circ}$ to $\pm15^{\circ}$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
Radar Presentation	Low Fidelity	Low Fidelity	
Bridge Presentation	Full Bridge	Full Bridge	
Ownship Characteristics	Shallow Water	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Preprogrammed	None	
Training Assistance Technology	Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 6. RESTRICTED WATERS NAVIGATION - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Techniques			
Knowledge of Requirements	Various Tecnniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
TRAINING PROGRAM			
Instructor Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	5 Days (40 hrs)	3 Days (24 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea	Pilot License (Minimum 3 Years At-sea)	

TABLE 6. RESTRICTED WATERS NAVIGATION - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor's Course	Educational Certificate	
Subject Knowledge	Exhaustive knowledge	Satisfactory knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 7. RULES OF THE ROAD - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Coastal	
Horizontal FOV	120^0 to 240^0	120^0 to 240^0	
Vertical FOV	$\pm 1^0$ to $\pm 15^0$	$\pm 10^0$ to $\pm 15^0$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
Radar Presentation	Low Fidelity	Low Fidelity	
Bridge Presentation	Full Bridge	Reduced Bridge	
Ownship Characteristics	Special Effects	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneuverable	Preprogrammed	
Training Assistance Technology	- Remote Monitoring - Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 7. RULES OF THE ROAD - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Tecnniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
TRAINING PROGRAM			
Instructor Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	3 Days (24 hrs)	1 Day (8 hrs)	
Class Size	6 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea)	Pilot License (Minimum 3 Years At-sea)	

TABLE 7. RULES OF THE ROAD - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor's Course	Educational Certificate	
Subject Knowledge	Exhaustive knowledge	Satisfactory knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 8. VESSEL-TO-VESSEL COMMUNICATIONS - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Restricted Waters - Generic	
Horizontal FOV	120° to 240°	120° to 240°	
Vertical FOV	±10° to ±15°	±10° to ±15°	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
SIMULATOR DESIGN			
Radar Presentation	Low Fidelity	Low Fidelity	
Bridge Presentation	Full Bridge	Reduced Bridge	
Ownship Characteristics	Special Effects	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneuverable	Preprogrammed	
Training Assistance Technology	- Remote Monitoring - Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 8. VESSEL-TO-VESSEL COMMUNICATIONS -
TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGPAM (Continued)			
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
Instructor Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	3 Days (24 hrs)	1 Days (8 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea	Pilot License (Minimum 3 Years At-sea)	

TABLE 8. VESSEL-TO-VESSEL COMMUNICATIONS -
TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor's Course	Educational Certificate	
Subject Knowledge	Exhaustive knowledge	Satisfactory knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 9. ADVANCED VESSEL-TO-VESSEL COMMUNICATIONS - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Restricted Waters - Generic	
Horizontal FOV	120^{0} to 240^{0}	120^{0} to 240^{0}	
Vertical FOV	$\pm 10^{0}$ to $\pm 15^{0}$	$\pm 10^{0}$ to $\pm 15^{0}$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
Radar Presentation	Low Fidelity	Low Fidelity	
Bridge Presentation	Full Bridge	Reduced Bridge	
Ownship Characteristics	Special Effects	Shallow Water	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneuverable	Independently Maneuverable	
Training Assistance Technology	- Remote Monitoring - Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Direct Skill Improvement	Direct Skill Improvement	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 9. ADVANCED VESSEL-TO-VESSEL COMMUNICATIONS - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Techniques			
Knowledge of Requirement	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi-media	Single Exercise, Verbal	
Instructor Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	3 Days (24 hrs)	1 Day (8 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea	Pilot License (Minimum 3 Years At-sea)	

TABLE 9. ADVANCED VESSEL-TO-VESSEL COMMUNICATIONS - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Instructor Credentials	Instructor's Course	Educational Certificate	
Subject Knowledge	Exhaustive Knowledge	Satisfactory Knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 10. DECISIONMAKING - TRAINING SYSTEM GUIDELINES

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
SIMULATOR DESIGN			
Visual Scene			
Geographic Area	Restricted Waters - Generic	Restricted Waters - Generic	
Horizontal FOV	120^{o} to 240^{o}	120^{o} to 240^{o}	
Vertical FOV	$\pm 10^{o}$ to $\pm 15^{o}$	$\pm 10^{o}$ to $\pm 15^{o}$	
Time of Day	Day/Night	Night Only	
Color	Multi-color	Black and White	
Radar Presentation	Low Fidelity	Low Fidelity	
Bridge Presentation	Full Bridge	Full Bridge	
Ownship Characteristics	Special Effects	Special Effects	
Exercise Control	Instructor Exercise Control	Exercise Selection	
Traffic Vessel Control	Independently Maneuverable	Independently Maneuverable	
Training Assistance Technology	- Remote Monitoring - Feedback Displays	None	
Availability	High Availability	High Availability	
TRAINING PROGRAM			
Skill After Training	Apprentice - Direct Skill Improvement Others - Refresher Training	- Direct Skill Improve- - Refresher Training	
Skill Before Training	Evaluation Via Dission	No Diagnostic Evaluation	
Training Objectives	Highly Structured	Moderately Structured	

TABLE 10. DECISIONMAKING - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
TRAINING PROGRAM (Continued)			
Training Techniques			
Knowledge of Requirements	Various Techniques	Various Techniques	
Positive Guidance	Various Techniques	Various Techniques	
Adaptive Training	Group Adaptive	No Adaptive Training	
Postproblem Critique	Single Exercise, Multi- media	Single Exercise, Verbal	
Instructor Guide	Documented Instructor's Guide	Undocumented Instructor's Guide	
Classroom Support Material	Advanced Support Media	Basic Support Media	
Simulator/Classroom Duration	Prebriefing/Simulation Postbriefing Mix	Simulation/Postbriefing Mix	
Training Program Duration	3 Days (24 hrs)	3 Days (24 hrs)	
Class Size	3 Or Less Students	6 Or Less Students	
Scenario Design	Various Levels	Various Levels	
Number of Scenarios	Desired Practice	Moderate Practice	
Stress	Progressive Stress	Progressive Stress	
Overlearning	Desired Overlearning	No Overlearning	
INSTRUCTOR			
Mariner Credentials	Pilot License (Minimum 10 Years At-sea	Pilot License (Minimum 3 Years At-sea)	
Instructor Credentials	Instructor Course	Educational Certificate	

TABLE 10. DECISIONMAKING - TRAINING SYSTEM GUIDELINES (Continued)

Critical Characteristics	Recommended Levels	Minimum Levels	Evaluator's Comments
INSTRUCTOR (Continued)			
Subject Knowledge	Exhaustive Knowledge	Satisfactory Knowledge	
Instructor Skills	Outstanding	Acceptable	
Instructor Attitude	Enthusiastic	Reserved	
Student Rapport	Respected	Competent	
Instructor Evaluation	- Continuing - Diagnostic	- Continuing - Diagnostic	

TABLE 11. EVALUATION SUMMARY: EMERGENCY SHIPHANDLING

SIMULATOR DESIGN

Excellent Satisfactory Marginal Unsatisfactory

Comments: 180° HORIZONTAL FIELD OF VIEW LIMITS SOME EXERCISES. SIMULATION OF BANK EFFECTS - POOR; HOWEVER SELDOM REQUIRED DURING EXERCISES. FEEDBACK DISPLAYS - DEFINITE PLUS.

TRAINING PROGRAM

Excellent Satisfactory Marginal Unsatisfactory

Comments: APPROPRIATE TRAINING OBJECTIVES IDENTIFIED AND EMPLOYED. POSITIVE GUIDANCE AND GROUP ADAPTIVE TRAINING EMPHASIZED. SCENARIO DESIGN ACCEPTABLE; HAVE SUGGESTED SEVERAL IMPROVEMENTS.

INSTRUCTOR

Excellent Satisfactory Marginal Unsatisfactory

Comments: STRONG MARINER AND INSTRUCTOR CREDENTIALS. EXCELLENT RAPPORT WITH STUDENTS. UNDERSTANDS THE UNIQUE PROBLEMS IN OUR PILOTAGE AREA.

OVERALL

ACCEPTABLE UNACCEPTABLE

Comments: RECOMMEND THAT THE ASSOCIATION ENROLL FOUR EXPERIENCED PILOTS IN THIS TRAINING PROGRAM FOR FURTHER EVALUATION.

BIBLIOGRAPHY

Eysenck, M.W. "Arousal, Learning and Memory" in **Psychological Bulletin**, 83: pp. 389-404, 1976.

Federal Register, Volume 48, No. 19, Thursday, January 27, 1983, p. 3914.

Fitts, P.M. "Factors in Complex Skill Training" in R. Glaser (ed.) **Training Research and Education**. Wiley, New York, 1965.

Gardenier, J.S. and D.T. Jones. "Clear Communications Could Curtail Collisions". **Annual Meeting Report of Radio Technical Commission For Maritime Services.** Memphis, Tennessee, April 27-29, 1981.

Gynther, J.W., T.J. Hammell, J.A. Grasso and V.M. Pittsley. **Simulators for Mariner Training and Licensing: Guidelines for Deck Officer Training Systems.** U.S. Coast Guard and Maritime Administration, Washington, D.C., 1982.

Hammell, T.J., J.W. Gynther, M.E. Gaffney, J.A. Grasso. **Simulators for Mariner Training and Licensing. Phase 2: Investigation of Simulator Characteristics for Training Senior Mariners.** U.S. Coast Guard and Maritime Administration, Washington, D.C., 1981.

Hammell, T.J., J.W. Gynther, and V.M. Pittsley. **Experimental Evaluation of Simulator-based Training for Marine Pilots.** U.S. Coast Guard and Maritime Administration, Washington, D.C., 1984.

Huffner, J.R. **Pilotage in Confined Waterways of the United States: A Preliminary Study of Pilot Decisionmaking.** Maritime Institute of Technology and Graduate Studies. Linthicum Heights, Maryland, July 1976.

Huffner, J.R. **Pilotage in the Port of New York.** Maritime Institute of Technology and Graduate Studies. Linthicum Heights, Maryland, July 1978.

Hussem, J., C. DeBoer and P.J. Paymans. "Seven Years Experience with Simulator Training of VLCC Pilots in the Netherlands", **Proceedings of the Second International Conference on Marine Simulation.** Computer Aided Operations Research Facility, Kings Point, New York, June 1981.

Krahenbuhl, G.S., P.W. Darst, J.R. Marett, L.C. Reuther, S.H. Constable. **Undergraduate Pilot Training: Instructor Pilot Behavior and Student Stress and Performance.** HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas, AFHRL-TR-80-15, July 1980.

Maritime Transportation Research Board. **Proceedings: Symposium on Piloting and VTS Systems.** National Academy of Sciences, Washington, D.C., 1980.

Paramore, B. and P. King. **Study of Task Performance Problems in Reports of Collisions, Rammings and Groundings in Harbors and Entrances.** Operations Research, Incorporated, Silver Springs, Maryland, March 1979.

Willms, O. "The Training of Pilots on a Shiphandling Simulator", Proceedings of the Second International Conference on Marine Simulation. Computer Aided Operations Research Facility, Kings Point, New York, June 1981.